SUPER GOOD CENTS BUILDER'S FIELD GUIDE

Bonneville
POWER ADMINISTRATION

The Builder's Field Guide was produced for the Bonneville Power Administration by Ted Haskell and Bryan Boe, Oregon State University Extension Energy Program. Editor/design: Lisa Schwartz. Illustrations: Coleen Stevenson, Thom Porterfield, and Bill Lanham. The guide presents construction details that may be used to meet requirements of the 1994 Long Term Super Good Cents® program offered by electric utilities throughout the Northwest.

SUPER GOOD CENTS BUILDER'S FIELD GUIDE

to Energy Efficient Construction

Built to the 1994
Super Good Cents
Standards

Table of Contents

List of Figures

Chapter 5: Electrical Contractor

Chapter 6: Plumbing Contractor

Chapter 7: HVAC Contractor

Chapter 9: Air Tightening Specialist

Chapter 10: Insulation Contractor

Introduction

The Builder's Field Guide presents approaches to energy efficient construction used throughout the Pacific Northwest. Builders can use the guide to meet standards of the Super Good Cents® energy efficient home program. But the construction techniques the guide describes can help improve the energy efficiency of any home.

Super Good Cents specifications are based on Model Conservation Standards developed by the Northwest Power Planning Council, a regional power planning body created by the 1980 Northwest Electric Power Planning and Conservation Act.

The Super Good Cents program is a voluntary approach to meeting Model Conservation Standards. Electric utilities in the Northwest encourage energy efficient new home construction because it is generally less expensive to conserve electrical energy than to build new power generating facilities. And it is less costly to install efficiency measures during home construction than it is to install equivalent measures into existing homes.

Throughout the Builder's Field Guide, you will find references to 1994 Long Term Super Good Cents (LTSGC) specifications***—1994 LTSGC 2.2.1,*** for example. Refer to these specifications, included as an Appendix to the Builder's Field Guide, for specific requirements. Utilities sometimes have additional requirements or tailor standards to meet local needs.

Program specifications change over time. Specifications in this publication went into effect in January 1994. Consult the participating Super Good Cents utility for the most current program information.

Homes built to 1994 Super Good Cents standards have significantly better energy performance than homes built to 1994 energy codes in all Northwest states. But in some cases, specific state or local code requirements exceed Super Good Cents specifications. **WHERE LOCAL CODE REQUIREMENTS EXCEED SUPER GOOD CENTS STANDARDS, LOCAL CODE REQUIREMENTS MUST BE MET.**

The Builder's Field Guide follows the construction sequence and explains the energy efficiency details that must be addressed at each stage to meet Super Good Cents performance standards. You can photocopy the appropriate chapter for each crew member or subcontractor so they have the energy efficient construction details they need. Or discuss the issues raised in each chapter as bids are developed and as work proceeds.

DECIDING TO BUILD AN ENERGY EFFICIENT HOME: A SIMPLE WAY OF EVALUATING INVESTMENTS IN ENERGY EFFICIENCY

In most cases, building homes to Super Good Cents standards costs more than meeting state energy code requirements. Is the additional cost worth it?

You can analyze the additional cost as an investment and compare the return on investing in energy conservation or renewable energy to other investments you could make.

A "Rate of Return" method allows you to compare energy savings investments to savings account interest, stocks, or mutual funds, for example. In its simplest form, the rate of return is the annual dollar savings divided by the capital cost.

Step One: Calculate Net Capital Cost

The net capital cost is the price minus anything that reduces the price, such as incentives, tax credits, deductions, and manufacturer rebates.

Example:

Suppose that proposed energy improvements to a home cost $1,100 and qualify for a $100 tax credit. The net capital cost would be $1,000.

Step Two: Calculate the Annual Savings

Use the best available information to calculate the average annual savings. In the case of house envelope measures, use a computer program that estimates energy use such as SUNDAY or WATTSUN to compute estimated annual energy use with and without energy improvements. Multiply the difference by the cost per energy unit to determine annual dollar savings.

Example:

WATTSUN tells you that the house with the improvements uses 3.0 kWh/ft^2/yr. The house without improvements uses 4.0 kWh/ft^2/yr. The house floor area is 2,000 ft^2.

3.0 kWh/ft^2/yr x 2,000 ft^2 = 6,000 kWh/yr

4.0 kWh/ft^2/yr x 2,000 ft^2 = 8,000 kWh/yr

The difference in energy use is 2,000 kWh/yr.

If electricity costs $0.05/kWh, the estimated annual savings is 2,000 kWh x $0.05/kWh = $100

Step Three: Calculate the Tax Free Income Advantage

Like other investments, savings from energy conservation and renewable energy puts dollars into your pocket, but you do not have to pay income tax on it! Estimate the tax you would pay on the savings if it were taxable. Add that figure to the savings for a fair comparison with return on taxable investments.

Example:

On $100 a person in the 28 percent tax bracket pays 0.28 x $100 = $28 in federal income tax. If the state charges income tax, estimate that also and add to the annual energy savings.

Step Four: Adjust for Inflation

With your conservation investment, you shield money from inflation as you would with any income-producing, long-term capital asset. Liquid assets, however, are subject to inflation. Add the avoided cost of inflation to your cash flow stream for a fair comparison. Multiply the net capital cost by the annual inflation rate. Add the avoided cost of inflation to the annual energy savings.

Example:

Inflation is 3.5 percent per year. $1,000 x 0.035 = $35/yr in avoided inflation cost.

Step Five: Add All the Positive Annual Cash Benefits

Example:

Energy savings	$100
Tax benefit	28
Avoided inflation	35
Total annual cash benefit	$163

Step Six: Divide Annual Cash Benefits by Net Capital Cost

Example:
\$163/\$1,000 =16.3%

Step Seven: Compare Pre-Tax Rates of Returns

Example:

Savings account	4.5%
Money market	4.9%
CDs	6.75%
Mutual fund	15%
Conservation investment	16.3%

As you can see, conservation investments can be good income producers and tax and inflation shelters. You can use the rate of return method to assess investments in envelope measures, heating system improvements, solar water heaters, exhaust air heat pumps, energy efficient lighting, and a host of other investments in energy conservation and renewable energy.

Chapter 1
Home Designer

A plan review by the participating Super Good Cents utility is the basis for qualifying each Super Good Cents home. If plans do a thorough job of showing required features, plan review is quicker, bids are more accurate, and the building process goes smoother.

In most cases, Super Good Cents requirements exceed state energy codes. Subcontractors bidding and constructing Super Good Cents homes tend to be misinformed if Super Good Cents details are not shown on plans. Especially important are clear details for insulation and ventilation systems. It is helpful if plan notes reflect special equipment performance standards—air leakage-tested, IC rated recessed lights, for example.

Agreements between the utility and builder are based on what is shown on the plans. If changes are made during construction, the Super Good Cents utility representative must reevaluate the plan to see whether the house still meets program performance standards.

This chapter identifies details Super Good Cents utility representatives look for as they review plans.

DESIGN REVIEW

The Builder's Field Guide shows many ways of meeting Super Good Cents program requirements. Read through the guide so you are familiar with energy conservation and other measures that must be installed at each stage of the construction sequence. Drawings may be photocopied or redrawn as needed. Super Good Cents utilities don't necessarily require that things get done exactly the way they're shown in this guide, as long as basic program requirements are met.

Many utilities use a "Plan Intake Checklist" to verify that plans are complete before they review them. The sample Plan Intake Checklist that follows lists details needed to demonstrate compliance with Super Good Cents specifications. Many of the items already are included on typical plans. Some listed items may not apply to all homes.

Use the sample checklist to help determine if Super Good Cents plan details are complete. If some items are not clear, ask the Super Good Cents utility for help.

PLAN INTAKE CHECKLIST

Italicized items are needed for Energy Budget qualification only.

Items in boxes apply only to optional measures.

1) SITE PLAN

Non-solar designs

North arrow	yes__ no__

Solar designs/Sun tempered

North arrow	*yes__ no__*
Lot size	*yes__ no__*
Street location	*yes__ no__*
House location on lot	*yes__ no__*
Lot corner elevations	*yes__ no__*
Lot to south	*yes__ no__*
Sun chart	*yes__ no__*

2) FLOOR PLANS

Show heated vs. unheated space	yes__ no__
Show vaulted ceilings	yes__ no__
Window dimensions	yes__ no__
Exterior door dimensions	yes__ no__

Non-heat recovery ventilation system details

Spot fans:

Locations	yes__ no__
CFM ratings	yes__ no__

Whole house fan:

Location	yes__ no__
Exhaust terminal type	yes__ no__
CFM rating	yes__ no__
Sone rating	yes__ no__
Fan controls	yes__ no__
Fresh air intake locations	yes__ no__
Damper locations (if necessary)	yes__ no__

Heat recovery ventilation system details

Unit location	yes__ no__
Unit make, model	yes__ no__
Unit CFM	yes__ no__
Condensate drain	yes__ no__
Supply air locations	yes__ no__
Supply air fitting type	yes__ no__
Exhaust air locations	yes__ no__
Exhaust air fitting type	yes__ no__
House volume	yes__ no__
Duct insulation	yes__ no__
Duct sealing	yes__ no__

3) ELEVATIONS

Footing to roofline	yes__ no__
All sides	yes__ no__
Window sizes, types	yes__ no__
Ventilation intake/ exhaust locations	yes__ no__
Skylight locations	yes__ no__

4) WINDOWS/SKYLIGHTS

Manufacturer	yes__ no__
Model numbers	yes__ no__
Frame type	yes__ no__
Glass type	yes__ no__
Window RO sizes	yes__ no__
NFRC tested U-factors	yes__ no__
Skylight manufacturer	yes__ no__

PLAN INTAKE CHECKLIST

Skylight
model numbers yes__ no__
Skylight frame type yes__ no__
Skylight glass type yes__ no__
Skylight sizes yes__ no__
NFRC tested
U-factors yes__ no__

5) EXTERIOR DOORS
Manufacturer yes__ no__
Configuration
(panel/flush) yes__ no__
Door material
(wood/metal/
fiberglass) yes__ no__
Door RO sizes yes__ no__
Tested U-factors yes__ no__

6) SECTION DRAWINGS
Footing to roofline yes__ no__
Stem wall/foundation:
Ventilation yes__ no__
Ground cover yes__ no__
Slab:
R-value perimeter yes__ no__

R-value
under slab yes__ no__

Gravel base yes__ no__
Moisture barrier yes__ no__
Floor:
R-value yes__ no__
Framing system yes__ no__
Vapor retarder yes__ no__
Wall:
R-value yes__ no__
Framing system yes__ no__
Vapor retarder yes__ no__
Ceilings:
R-value yes__ no__
Framing system yes__ no__
Vapor retarder yes__ no__
Attic ventilation yes__ no__
Roof pitch yes__ no__

7) AIR LEAKAGE CONTROL DETAILS
Air leakage details
noted yes__ no__
Air leakage specs
attached yes__ no__

8) HEATING SYSTEM
Heating system type yes__ no__
Unit location(s) yes__ no__
Duct R-value yes__ no__
Duct sealing yes__ no__
Thermostat locations yes__ no__

9) APPLIANCES

Water heater:
Manufacturer yes__ no__
Model number yes__ no__
Insulated pad (@
uninsulated floors) yes__ no__
Energy factor yes__ no__

Exhaust air
heat pump yes__ no__

Gas or oil appliances:
Sealed combustion yes__ no__
Induced draft yes__ no__

Wood stoves/fireplaces:
Location yes__ no__
Outside
combustion
air to firebox yes__ no__

PLAN INTAKE CHECKLIST

Recessed lights:

Locations noted	yes__ no__
Located	yes__ no__
Air leakage tested	yes__ no__
Insulated above/ sealed	yes__ no__

Interior lighting option:

General kitchen luminaires 50 lumens/watt	yes__ no__
CRI 79+	yes__ no__
Other lights on separate switches	yes__ no__
Kitchen lighting budget 2 watts/ft^2	yes__ no__

Exterior lighting option:

Maximum 4 luminaires per unit, 50 lumens/watt	yes__ no__
If operated by photocell - metal halide, high pressure sodium or minimum 9-watt fluorescent	yes__ no__
Operated by motion sensor	yes__ no__

QUALIFICATION OPTIONS - THERMAL ENVELOPE

Home designers can perform their own qualification analysis. But final qualification of a house plan is done by the Super Good Cents utility representative. Once the plan is near completion, visit the utility representative to find out if the plan qualifies as is or if changes are needed. That way final plan drawings can show exactly what's needed to qualify the home.

Both prescriptive and performance qualification methods are available. Many requirements address the thermal envelope of the building, but other requirements, concerning appliances, ventilation, and heating systems, also must be met. The first step is "Get the thermal envelope qualified." Step 2 is "Take care of other requirements."

Prescriptive Paths: LTSGC 1.2

Prescriptive paths specify component conservation levels. A prescriptive path is like a recipe: If listed R-values and U-factors are shown on plans and installed, the home meets Super Good Cents thermal standards. It's important to remember that Super Good Cents requirements for air leakage control, heating controls, and ventilation systems also must be met.

TIP: R-values are ratings of an insulation's resistance to heat flow. The higher the R-value, the better the resistance. U-factors are heat loss rates. They're typically used for rating efficiency of windows, skylights, and doors. The lower the U-factor, the lower the heat loss.

When reading prescriptive paths, the listed R-value is the lowest R-value allowed by that path. The U-factor is the highest U-factor allowed by that path.

In prescriptive paths, R-value requirements refer to the nominal R-value of the insulation, rather than overall R-value of the component. A prescriptive R-26 wall, for example, has insulation materials that total R-26. Prescriptive qualification does not recognize R-values of other building materials in the wall such as siding and framing.

U-factors in prescriptive paths refer to the rate of heat transfer for the entire component. The U-factor for a window, for example, includes the glazing, frame, sash, and edge spacers.

You'll sometimes run into something called an F-factor, a heat loss rate for concrete slab edges. The F-factor refers to heat loss per lineal foot, whereas U-factor refers to heat loss per square foot.

Your Super Good Cents representative can help you find approved R-values, U-factors, and F-factors.

Table 1.1
MCS REFERENCE PATH
(for Super Good Cents program beginning 1994)

COMPONENT		NOMINAL VALUES	REFERENCE U-FACTOR	
Ceilings	Attic	R-49 Advanced Framing		U-0.020
	Vault	R-38		U-0.027
Walls	Above Grade	R-26 Advanced Framing (Standard Framing in multifamily)		U-0.041 (U-0.044)
	Below Grade Interior (with R-5 slab edge thermal break)	R-21	2 ft below grade:	U-0.042 F-0.592
			3.5 ft below grade:	U-0.040 F-0.556
			7 ft below grade:	U-0.035 F-0.503
Floors	Over Crawl Space and Unheated Basement	R-30 (R-38 in Climate Zone 3)		U-0.029 (U-0.025)
	Slab-0n-Grade Perimeter	R-15		F-0.52
Glazing	(maximum tested U-factor)	U-0.35		U-0.35
Exterior Doors	(maximum tested U-factor)	U-0.19		U-0.19
Duct Insulation		R-11 (rigid duct) R-8 (flex duct)		
Air Leakage		Standard Super Good Cents air sealing		
Water Heater		From Super Good Cents utility list		
Ventilation		50 CFM in bathrooms (20 CFM if continuous)		
		100 CFM in kitchens (25 CFM if continuous)		
		Whole house ventilation sized to house		

Notes:

Reference U-factors are developed from total component performance, including insulation, framing, sheathing, finish materials, etc. To be equivalent to the MCS Reference Path, a component must have a U-factor equal to or less than the Reference U-factor. Residences that comply with all measures listed in this table may have unlimited glazing area.

The disadvantage of using a prescriptive path is that it lacks flexibility. You have to follow the path exactly to qualify for the program. The advantage of using a prescriptive path is that it's simple. The only calculations needed are for floor and window areas.

There are two sources of prescriptive paths. One is called the "MCS Reference Path for Electrically Heated Residences," section 1.2 of the Super Good Cents specifications. The path is outlined in Table 1.1 on page 10. If you follow this path to the letter, there are no restrictions on glazing areas (windows, skylights, and glass doors). The other source for prescriptive paths is your local Super Good Cents utility. If the utility has developed its own special prescriptive option, glazing limits may apply.

Performance Calculations

Performance calculations allow more flexibility. You can trade higher efficiency in one part of the building for lower efficiency in another part. Let's say you can get a good price on high efficiency windows. With high efficiency windows in your design, you might be able to reduce R-values in the walls and still qualify the home. And you might save money compared to following a prescriptive path.

Typically, the Super Good Cents utility representative calculates energy performance using the WATTSUN computer program. If the house as designed doesn't qualify, the Super Good Cents representative can tell you what it would take to qualify the house.

Two measures of performance can be used for Super Good Cents qualification: Thermal Performance or Energy Budget. The house must qualify using *either* performance measure. It doesn't need to qualify under both. The WATTSUN computer program calculates both. The principle behind both calculations is to come up with a set of conservation measures that are equivalent in performance to measures in the MCS Reference Path (Table 1.1). So to qualify, you need to do calculations for the house two ways:

1. **Reference House.** First, calculate performance of the "Reference House." This is the house design you plan to build, but with R-values and U-factors matching the MCS Reference Path (Table 1.1). Rather than using the window area you plan to build, assume window area is 15 percent of heated floor space area. Window area is distributed so that 25 percent is on each cardinal compass point. For example, a 2,000 ft^2 Reference House has 300 ft^2 of windows, with 75 ft^2 each on the north, south, east, and west sides of the house: 2,000 ft^2 X 0.15 X 0.25 = 75 ft^2.

2. **Proposed House.** Next, calculate performance of the "Proposed House"—the house with the R-values, U-factors, glazing areas, and glazing orientations that you actually plan to build. If the performance of the Proposed House is equal to, or better than, performance of the Reference House, your

Proposed House qualifies. If the Proposed House doesn't qualify, make changes to your design and recalculate.

You can do these calculations using the WATTSUN computer program that Super Good Cents utility representatives use. It's available from the Washington State Energy Office, 925 Plum St. SE, Building 4, Olympia, WA 98504-3165; (360) 956-2031. The program runs on IBM-compatible hardware. The software purchase price includes a manual, phone support, and periodic technical bulletins and updates.

Thermal Performance Approach

The Thermal Performance approach is a calculation of the heat loss rate of the overall structure ("UA_o"). If "UA_o" of the Proposed House is the same or lower than "UA_o" of the Reference House, the Proposed House qualifies. UA_o represents a heat loss rate in Btu/hour/°F. It may be calculated in a number of ways. Rather than using a mathematical formula, most designers find it faster to use a computer or a worksheet that looks like Table 1.2 on page 13.

Use a photocopy of Table 1.2 for each thermal performance calculation. The left side of the worksheet is for the Reference House. The right side is for the Proposed House. The U- or F-factors for the Reference House are already filled in. These are the U- and F-factors that correspond to the MCS Reference Path (Table 1.1).

Note that window area for the Reference House is 15 percent of total heated floor area, regardless of actual window area you plan to use. Also note that F-factors rather than U-factors are used for slabs. Most of a slab's heat loss is at the edge, so you enter the length of the slab perimeter in linear feet, rather than the slab's area. (Super Good Cents homes must have insulation between slabs in heated spaces and slabs in unheated spaces. Include this boundary when figuring the perimeter length of a slab. See Chapter 3.)

On the right side of Table 1.2, enter U- and F-factors that correspond to insulation levels you plan to use for walls, floors, and ceilings. A list of approved U- and F-factors for various building components is included with the specifications in the back of this guide. See Default Heat Loss Coefficients, Exhibit X, Reference 20. For windows, skylights, and doors, enter *NFRC tested* U-factors, available from manufacturers, distributors, and your Super Good Cents utility. Enter glazing areas you plan to use for the house.

If you prefer, you may use the following formula to establish UA_o for the Reference and Proposed Houses:

Table 1.2
THERMAL PERFORMANCE CALCULATIN WORKSHEET

		REFERENCE		PROPOSED		
COMPONENT	DIMENSIONS	HEAT LOSS RATE	HEAT LOSS (Area X Heat Loss Rate)	DESCRIPTION	HEAT LOSS RATE	HEAT LOSS (Area X Heat Loss Rate)
Heated Floor Area	___ sq ft					
Below Grade						
Avr. Depth 2 ft Wall Slab	 ___ sq ft ___ lin ft	 U=0.042 F=0.592			 U = ___ F = ___	
Avr. Depth 3.5 ft Wall Slab	 ___ sq ft ___ lin ft	 U=0.040 F=0.556			 U = ___ F = ___	
Avr. Depth 7 ft Wall Slab	 ___ sq ft ___ lin ft	 U=0.035 F=0.503			 U = ___ F = ___	
Slab On Grade	___ lin ft	F=0.520			F = ___	
Floors (over unheated spaces)	___ sq ft	U=0.029* or U=0.025*			U = ___	
Windows (Reference)	___ sq ft (heated floor area x 0.15)	U=0.35				
(Proposed type 1)	___ sq ft (actual)				U = ___	
(Proposed type 2)	___ sq ft (actual)				U = ___	
(Proposed type 3)	___ sq ft (actual)				U = ___	
Glass Doors	___ sq ft				U = ___	
Opaque Doors	___ sq ft	U=0.19			U = ___	
Net Walls (gross wall minus windows, doors)	___ sq ft	U=0.041			U = ___	
Skylights	___ sq ft				U = ___	
Net Ceilings (gross ceiling minus skylights)						
Flat	___ sq ft	U=0.020			U = ___	
Vault	___ sq ft	U=0.027			U = ___	
Air Leakage	___ cu ft	0.0063			0.0063** or 0.0036**	
TOTAL						

*Use 0.029 for Climate Zones 1 and 2. Use 0.025 for Climate Zone 3 (Ask your utility if you don't know what Climate Zone you're building in.)
**Use 0.0063 for Standard Air Leakage Control. Use 0.0036 for Advanced Air Leakage Control

THERMAL PERFORMANCE FORMULA

U_oA_o = (Fbs X Pbs) + (Ubw X Abw) + (Fs X Ps) + (Ug X Ag) + (Ud X Ad) + (Uw X Aw) + (Uf X Af) + (Uc X Ac) + (Infil)

Where:

U_oA_o = Overall building Thermal Performance (Btu/hour/°F)
Fbs = F-factor of below grade slab
Pbs = Perimeter of below grade slab
Ubw = U-factor of below grade wall
@ 2 ft depth
@ 3.5 ft depth
@ 7 ft depth
Abw = Area of below grade wall
@ 2 ft depth
@ 3.5 ft depth
@ 7 ft depth
Fs = F-factor of slab on grade
Ps = Perimeter of slab on grade
Ug = U-factor of glazing
Ag = Area of glazing
Ud = U-factor of door(s)
Ad = Area of door(s)
Uw = U-factor of wall
Aw = Area of wall [net area = gross area - (Ag + Ad)]
Uf = U-factor of floor over unheated space
Af = Area of floor
Uc = U-factor of ceiling
Ac = Area of ceiling
Infil = heat loss from air infiltration

Infil = (ach_{eff})(Vol)(C)

Where:
Infil = heat loss from air infiltration and ventilation
ach_{eff} = effective air changes per hour (including effect of heat recovery ventilation, if used):

Standard Air Leakage Control	$ach_{eff} = 0.35$
Advanced Air Leakage Control (with non-heat recovery ventilation)	$ach_{eff} = 0.30$
Advanced Air Leakage Control (with heat recovery ventilation)	$ach_{eff} = 0.20$

Vol = volume of heated space

C = heat capacity/density product (constant):

Sea level to 2,000 ft	C = 0.018
2,000 to 3000 ft	C = 0.0168
3,000 ft and above	C = 0.0162

Sources of U- and F-Factors

Default Heat Loss Coefficients (back of this guide)

or

Super Good Cents Heat Loss Reference Vol. 2 and 4

or

WATTSUN 5.5

Energy Budget Approach

An Energy Budget calculation is an estimate of annual building energy use. The estimate accounts for typical local weather conditions, building envelope performance, building orientation (to account for solar gains), internal gains (to account for heat from people and appliances), and losses from the duct system.

First, calculate a Reference House Energy Budget using the reference U-factors from Table 1.1. The Reference House is calculated with total window area equal to 15 percent of heated floor space area, equally distributed (25 percent of window area facing each cardinal compass point). Then, model the Proposed House using actual window area and distribution and proposed envelope conservation measures. If the Energy Budget for the Proposed House equals or is less than the Reference Energy Budget, the home qualifies. If the Proposed House doesn't meet the target Energy Budget, change the plans to bring the home into compliance. Indicate any changes on the plans.

You need computer software to calculate Energy Budgets. For a given design, WATTSUN can calculate Reference and Proposed Thermal Performance and Energy Budgets. The program makes it easy to analyze how design changes affect cost and energy efficiency so you can make the most cost-effective changes. If you are already using a computer program that generates Energy Budgets, check with your utility to see if the program's calculations are acceptable.

Provide the design reviewer with component areas and a list of conservation measures you plan to use. That speeds computer entry and review time.

Your Super Good Cents utility can provide you with a WATTSUN input worksheet and instructions to help you organize data and speed computer plan analysis.

OPTIONAL MEASURES

The Super Good Cents program includes optional measures that are not required for baseline participation in the program.

If you're installing optional measures, show them on the plans you submit to the utility representative.

Options available as of January 1994 are described in the Long Term Super Good Cents Specifications for Site Built Single and Multifamily Homes, in the back of this guide. Options include:

Advanced Air Leakage Control Option

Pass a blower door test standard of 1.8 ACH50.

Heat Recovery Ventilation Options

Air-to-Air Heat Exchanger. These are ducted ventilation systems that preheat incoming fresh air with waste heat from the outgoing stale air stream. To meet the requirements of this option, Standard Air Leakage Control measures are used for baseline house qualification, but additional prescriptive Advanced Air Sealing techniques also are installed. See Chapter 9. Not all air-to-air heat exchangers meet certified equipment efficiency standards, so you need to check. Plans should show manufacturer and model information, equipment location and layout, and note the Advanced Air Sealing techniques.

Exhaust Air Heat Pump - Water Heating Only. This ventilating equipment uses refrigeration technology to extract heat from the stale air exhaust to heat household water. Plans should show manufacturer and model information, location, and exhaust duct layout.

Exhaust Air Heat Pump - Water and Space Heating. Similar to water heating-only equipment, this unit adds a space heating option. When water heating needs are satisfied, the system can provide supplemental space heating (and cooling). Standard Air Leakage Control measures are used for baseline house qualification, but additional prescriptive Advanced Air Sealing techniques also are installed. See Chapter 9. Plans should show manufacturer and model information, equipment location and exhaust duct layout, and note the Advanced Air Sealing details.

Energy Efficient Lighting Options

Efficient Interior Lighting. The kitchen must have one energy efficient luminaire, on a separate switch, for general lighting. The combined wattage of kitchen lighting (excluding the range hood) must not exceed 2 watts/ft^2. See Chapter 5 for details. Plans should show fixture model information, lamp wattages, and power budgets (watts per square foot) for kitchens.

Outside/Common Area Lighting. Label entry lighting that meets efficiency requirements on plans. See Chapter 5. Include fixture model, lamp wattage and type, controls, and wiring.

Sub-Slab Insulation Option

Requirements for this option address full sub-slab insulation. In Climate Zone 1, insulation must be at least R-5. In Climate Zones 2 and 3, insulation must be at least R-10. If you're not sure which Climate Zone you're building in, check with your Super Good Cents utility. Plans should show sub-slab location, R-value, and type of insulation. Cross sections are the best places to show this information.

SUN TEMPERING

With their minimal heating requirements, Super Good Cents homes are natural candidates for solar heating designs whenever home sites have unshaded southern exposure. Though sophisticated passive solar designs can work well in the Northwest, solar designs most likely to be successful here are simple and inexpensive.

Sunlight turns into heat when it strikes objects inside the house. Materials inside the house store the heat and release it during nighttime hours. (If these materials store enough heat, they may release it for another day or two.) In cold, sunny winter climates, large areas of south facing glass and large amounts of thermal mass (concrete, masonry, and even water storage) have been used successfully, but these designs can be expensive to build. In cloudier parts of the Northwest, there may not be enough hours of sunlight to warm up large amounts of thermal mass.

The type of solar design that works for most Northwest homes is called “sun tempered.” Sun tempering means placing on the south side moderate amounts of glass—typically an area equivalent to about 8 percent of house floor area. For example, a 1,500 ft^2 house should have roughly 120 ft^2 (1,500 ft^2 X 0.08 = 120 ft^2) of windows facing south.

Advantages of sun tempering include:

- Better natural light during the daytime - Southern light cheers up a room, even on overcast days.
- Improved comfort from warmer surfaces - Sun-heated surfaces, such as walls and floors, radiate heat. People near these surfaces are warmer and more comfortable.
- Good southern views without an energy penalty - Larger areas of glass provide a good view to the south.
- Easier qualification under the Super Good Cents program – Solar heat gains may allow you to qualify a house that otherwise would be difficult or expensive to qualify.

Windows needn’t face exactly true south. Up to 30° east or west of true south is OK. Avoid concentrating window area in one or two rooms, unless they’re very large. Too much window area in a small room can overheat the room, especially during spring and fall. With 8 percent of floor area in south facing glass, most Super Good Cents homes have enough thermal storage mass to prevent overheating and keep the home warm most of the night. The thermal mass is in building materials (drywall, flooring, etc.) and household furnishings that are already in the house, so there’s no additional cost.

When choosing windows for the south face of the house, avoid window coatings that greatly reduce solar transmission. In general, tinted windows reduce solar heat gain. Don't use them on the south side of the house unless overheating is a major problem (in which case you have too much window area for sun tempered design).

Low-e windows reduce solar transmission compared to standard window glass. But they're suitable for south facing windows in sun tempered designs for two reasons: They reduce heat loss during hours of darkness (improving comfort and reducing heating costs), and they reduce transmission of ultraviolet light that damages fabrics and other furnishing materials. New, efficient low-e materials on the market have high *transmissivity* for greater light and heat gain and *low emissivity* for low heat loss.

Prevent Overheating

Many people worry that substantial south facing glass overheats a house on hot summer days. The good news is that in summer, the sun is nearly straight overhead most of the day, so south facing vertical glass doesn't gain much heat from direct solar radiation. You can reduce heat gain with overhangs that shade south facing windows during summer, but not winter. If the ground surface is a light color, there may be considerable gain from reflected solar energy, so avoid light ground colors in front of south facing windows.

Here are ways to design for cooling:

- Minimize east and west facing windows - They cause most summertime overheating. If the view is to the east or west, use tinted or reflective glass to reduce heat gain.
- Use movable shading devices to reduce heat gain - Exterior shades are most effective, but need to be designed carefully for easy operation. Movable devices work well because they can be opened for views and closed during peak heat gaining periods.
- Use shade screens - Good shade screens are made up of very small louvers. They're angled to provide shade and let you see well through the window. They may be most effective in cases where a movable shading device is too awkward to operate or too expensive. Occupants should remove shade screens from south facing windows during the heating season.
- Avoid large areas of overhead glazing - While small skylights (2x2 ft or 2x4 ft) are good for daylighting, large skylights can cause overheating during summer when the sun is nearly straight overhead.

Improve Daylighting

Large amounts of glass on only one side of a room can create an unpleasant glare. A strong light from one direction strains eyes trying to adjust to the strong light while the rest of the room is relatively dark.

Here are ways to avoid glare:

- Use light colored walls, floors, and ceilings to reflect incoming light deep into the room. That reduces contrasts with a strong window light source.
- Use small windows on (other than south facing) outside walls to get light deeper into the room. That reduces contrast with main window areas.
- Use a small skylight to get light to the back of a room. That reduces contrast with a strong window light source.

Solar Access

South facing windows capture significant solar heat only if they are unshaded in winter from mid-morning to mid-afternoon. To use solar heat gains to help qualify a house for the Super Good Cents program, solar glazing equal to or greater than 8 percent of the floor area must be installed on the south side and you must document that the “solar aperture” will be 80 percent unshaded from 9 a.m. to 3 p.m. during the heating season.

Obstructions to the south that can shade the house during winter include evergreen trees, buildings, and hillsides. Deciduous trees are considered to be half shading. If deciduous trees shade 30 percent of the solar aperture, for example, they only count as 15 percent shading.

You can document solar access with a sun chart. It shows the track of the sun throughout the year. Draw obstacles on the chart to determine whether they’ll shade solar glazing. A number of good books are available on passive solar design. They explain how to make a sun chart for a specific site. Your Super Good Cents representative can help you find books or professional assistance for making a sunchart or help you with other ways to document solar access.

Super Good Cents specifications also require that you document future solar access. You must show on your site plan that solar glazing will not be shaded by the shadow of a 6-ft fence on your southern property line.

You also must show that a “pole” as tall as average building heights in your area, in the center of the building lot to the south, will not shade solar glazing. Your Super Good Cents representative has information on how to calculate and document shadow lines or may be able to help you with alternative ways to document future solar access.

Some localities have ordinances that protect solar access. If these ordinances are comparable to Super Good Cents specifications for solar access, you may satisfy program requirements by complying with local ordinances. Check with your utility representative to see if the building site is protected by local solar access ordinances.

COMBUSTION APPLIANCES IN NEW HOMES

Fireplaces, Wood Stoves, Fireplace Inserts

Many Super Good Cents homes and new code homes include combustion appliances. Homes are tighter than they used to be. Combustion appliances in tight homes can be extremely sensitive to negative pressure environments created by exhaust-only ventilation devices in the home.

Kitchen range hood fans and dryers tend to be the strongest exhaust-only ventilators. But bath fans and any other device that pulls air out of a home can make it more difficult for a naturally vented, solid fuel appliance to sustain strong draft.

From a health and safety standpoint, it is recommended, but not required, that balanced ventilation systems such as air-to-air heat exchangers—as opposed to exhaust-only systems—be used for whole house as well as spot ventilation in homes with combustion devices. Typical ventilation in Super Good Cents homes currently consists of a balanced whole house system and unbalanced, exhaust-only spot ventilation.

For a discussion of interactions between mechanical systems and combustion appliances in homes, order the Reliable Chimney Venting Training Manual by John Gulland from Hearth Education Foundation, 3019 Perry Lane, Austin, TX 78731; 512-450-0987.

For information about balanced central ventilation systems, see the “Heat Recovery Ventilation” section of Chapter 7 in this guide, or order “Air-to-Air Heat Exchanger Systems: Marketing, Design and Installation,” a two-part training video tape and study guide, from Oregon State University Extension Energy Program, Batcheller Hall 344, Corvallis, OR 97331-2405;503-737-3004.

For information about house pressure tests that verify whether systems are balanced, contact your participating Super Good Cents utility or state technical assistance provider.

Chapter 2

General Contractor

The Builder's Field Guide is designed to help general contractors communicate about energy efficient construction details with each subcontractor on the job. This chapter covers details that need to be addressed early in the building process—to make sure building materials and supplies you order meet Super Good Cents specifications and to get subcontractors off on the right foot. It is important to communicate about Super Good Cents requirements with subcontractors, because if the subcontractor's work does not meet program specifications, the home may fail to qualify for the program.

If you build custom houses, it's common to have customers request changes during construction. Some changes will affect energy efficiency of the house—window, door and skylight changes, or changing flat ceilings to vaults, for example. These changes don't just affect *your* bottom line—they affect the *energy* bottom line too. So when you need to make a change that affects energy performance of the house, let your Super Good Cents utility representative know. Your representative will make sure the proposed changes don't knock your house out of the program.

THINGS TO DISCUSS WITH THE CONCRETE CONTRACTOR

Foundation/Slab Insulation

1994 LTSGC 2.1.8

Super Good Cents slab insulation R-values exceed most energy code standards. The concrete contractor needs to be reminded about extra insulation requirements for below grade slab edges (R-5) and on-grade slab edges (R-15). Sometimes walls for heated basements are insulated on the outside (R-21). If you have agreed to install optional full slab insulation, the concrete contractor must thermally break the slab from footings. The concrete contractor is most likely to assume code levels of insulation and will miss these details unless you point them out. If the concrete contractor does not place the right insulation the right way, your home does not meet LTSGC specifications. Show the concrete contractor the details in Chapter 3.

Typical R-values are:

Heated basement walls	R-21
Below grade slab perimeters (thermal break between foundation wall/footing and slab)	R-5
Slab on grade perimeters	R-15
Below slab insulation (optional measure)	R-5 to R-10

Extruded polystyrene is most commonly used below grade. It has high compressive strength, resists water penetration, and stands up well to abuse on the construction site. Extruded polystyrene has an R-value of about R-5 per inch.

Other materials also are suitable for below grade applications, including:

- High density expanded polystyrene (beadboard) - Typically R-3.5 to R-4 per inch. Check with the manufacturer for recommended applications (not all are suitable for below grade applications).
- High density fiberglass - Also used as drainage board. Typically R-4 per inch. Not widely marketed in the U.S.
- Polyurethane - Typically R-6 per inch. Check with the manufacturer for moisture protection requirements.

A common mistake when planning slab perimeter insulation is to forget to insulate slab edges adjacent to unheated spaces (such as garages). Your concrete contractor may not be used to separating the garage pour from the rest of the slab or crawl space stemwall with R-15. You need to point this out when getting bids. See Chapter 3 for details on how to insulate these areas.

Duct Chases Through Slabs

If a forced air furnace will be located in the garage, the concrete contractor may be responsible for boxing out a hole in the slab so the supply plenum can run from the garage to the crawl space. The box-out needs to be big enough for the plenum plus R-11 insulation on all sides of the plenum. If the concrete contractor misses this detail, the plenum cannot be insulated.

Slab Moisture Protection

1994 LTSGC 4.1.2

Most building codes call for a moisture barrier under the slab. Typically, 6 mil polyethylene or other material approved for below grade use is installed. For moisture protection, Super Good Cents specifications call for a minimum of 4 inches of gravel under a slab. The type of gravel specified provides a capillary break from ground water. However, some local building codes require a moisture barrier even if you pour over gravel, so you may need to put a moisture retarder down even if your Super Good Cents utility representative does not require it.

Crawl Space Ventilation

1994 LTSGC 4.2.2

If Super Good Cents specifications for crawl space ventilation exceed local code requirements, you need to calculate ventilation requirements (see Chapter 3) and make sure the concrete contractor puts enough vents in. If the foundation wall is high enough, have vents installed below the level of the floor insulation. This will avoid having to baffle vents to keep them clear of deeper floor insulation.

THINGS TO DISCUSS WITH THE FRAMING CONTRACTOR

Structural Panels With Low Formaldehyde Ratings

1994 LTSGC 4.4

If the framing contractor supplies framing materials, be sure he or she orders sheathing and structural panels bearing one of the following grade stamps: “Exposure 1,” “Exterior,” or “HUD-Approved.” The stamps indicate that products emit only low levels of formaldehyde. Structural sheathing that doesn’t bear these stamps doesn’t meet Super Good Cents specifications.

Keeping formaldehyde sources out of the house makes it a healthier place to live.

Advanced Wall Framing: Use Structural Sheathing Rated for 24 Inches on Center

If advanced wall framing is part of your agreement with the utility, make sure the framer uses sheathing and siding rated for 24-inch on center framing. See Chapter 4 for details on advanced framing.

Insulating Wall Sheathing

Many Super Good Cents homes qualify using R-26 walls. That typically requires rigid foam sheathing rated from R-5 to R-7.2. Foam insulation thickness can affect siding nail size, trim and corner details, and thickness of nailers. Make sure the framers are aware of proper installation details for foam sheathing. Chapter 4 shows details for installing rigid insulation on the interior or exterior wall surface.

Special Trusses

Plans for many Super Good Cents homes call for "advanced" roof/ceiling framing. You'll need special "energy" trusses that allow full insulation depth at the exterior wall. See Chapter 4 for details. If your agreement with your Super Good Cents utility calls for advanced ceilings (energy trusses) and standard trusses are installed, your house won't meet Super Good Cents specifications unless you improve energy efficiency of another part of the house.

Floor Framing Details

Check to see that the proposed floor insulation will really fit in the floor framing cavity. If floor framing depth and floor insulation depth don't match, insulation support systems will be needed to keep floor insulation in place. It's better to match the floor frame to the insulation depth.

Windows

1999 LTSGC 2.2.1

Windows either contribute to or reduce the home's energy efficiency. In general, because heat loss through windows is so high, the more windows a home has, the harder it is to qualify for the Super Good Cents program. An important exception to this rule is solar (southern) glazing, which usually helps qualify the home.

Make sure to order windows that meet U-factor requirements specified (0.35 or less) on approved plans.

U-factors describe the rate of heat transfer through a window unit. The lower the U-factor, the lower the rate of heat transfer, and the better the energy performance of the window.

Window U-factors accepted by the Super Good Cents program are determined by independent laboratory testing. 1994 Super Good Cents specifications require windows that have been NFRC (National Fenestration Rating Council) certified and labeled.

If you change windows in midstream, make sure the U-factor of the new window is equal to or lower (better) than the U-factor of the window it's replacing.

If you add window area after your Super Good Cents representative approves the plans, let your representative know so he or she can check whether the house still qualifies.

Your Super Good Cents utility representative can help you find U-factor information for most windows manufactured and sold in the Northwest. Window distributors also should have information on NFRC U-factors for windows they sell.

Some approved windows have slot vents. They provide air intake for the home ventilation system. Make sure they're installed in the locations shown on the plans. Stick with the approved windows, or be sure changes to windows don't affect compliance with ventilation specifications.

Exterior Doors

Entry and garage passage doors are part of the thermal envelope of a building. Their energy performance helps determine whether the home meets Super Good Cents specifications. Insulated metal and fiberglass doors are commonly used to qualify homes for the program. (Wood entry doors won't exclude a house from the program. They just make it a little harder to qualify.)

Changing doors can affect house qualification. It's better to plan on a glazed door when qualifying a home and change to a solid door than to qualify using a solid door and change to a glazed door during construction. If you're considering door changes, check with the Super Good Cents representative to make sure a door change doesn't knock you out of the program.

Skylights

Skylights also are part of the building's thermal envelope. Most lose heat more rapidly than windows. The plan approval process includes checking skylight sizes and models.

If you make changes that add skylights, or are considering alternates to approved models, make sure new skylights have a U-factor equal to or less than the skylights on the approved plans. Check with your Super Good Cents representative to be sure additional skylight area doesn't prevent the home from qualifying.

Skylights haven't been as widely tested as windows, but NFRC testing is proceeding. Your Super Good Cents representative or skylight dealer should have information on U-factors of locally available skylights.

Fan Jacks

One way to make sure ventilation systems work is to use short duct runs from the fans to the outside. Fan ducts work better if they terminate at dedicated fan jacks close to the fan—instead of running 20 feet to an attic vent at the other end of the building. The shorter the duct run, the better the fan works.

Have fan jacks (as well as attic vents) onsite during roof framing. Framers can cut holes for the jacks directly above bath, kitchen, and other fan locations. They can leave the jack pinned near the hole for the roofer to install. If you run fan ducts horizontally to the eave or gable end, pick the shortest run that involves the least amount of elbows. Remember that end fittings must terminate outside the house, not just near an eave vent.

TIP: Some fan jacks have a collar extending below the roof sheathing. The collar makes it easy to make a positive, sealed connection to the fan duct. Match jack collar size to fan duct size—typically 4 inches. Many fan manufacturers supply roof and wall jacks designed for their fans. Collars may be installed separately to allow a positive mechanical connection between the fan duct and fan jack.

Keep two things in mind if you use a fan jack:

1. You can't count this jack as roof ventilation if it's connected to a fan. You'll need to add another roof jack to your order.
2. Make sure the open area of the jack is at least as large as the area of the duct so the jack won't restrict airflow.

Through-the-Wall Fresh Air Intake Vents

1994 LTSGC 4.3.7, 4.3.8, 4.3.9

Many Super Good Cents homes have a ventilation system that includes through-the-wall fresh air intake vents in each bedroom and one for each 300 ft^2 of main living area. Slot vents in windows may be used in place of through-the-wall vents.

Exhaust fans draw small amounts of fresh air into the home through intake vents. Vents are "designed holes" in the building envelope, sized to provide small amounts of fresh air. They're placed near the ceiling to provide fresh air without creating noticeable drafts.

Your Super Good Cents representative can help you find suppliers for through-the-wall vents.

Window Fresh Air Vents

1994 LTSGC 4.3.7, 4.3.8, 4.3.9

Window slot vents are an alternative to through-the-wall vents. These closeable vents provide a slow flow of fresh air when exhaust fans operate. Windows with slot vents need to be in each bedroom and in main living areas. Make sure the framers install vented windows in locations marked on the plans.

Framing Systems

Choices of framing systems and materials for floors, walls, and ceilings have a significant impact on the building's energy performance. See Chapter 4 for details on energy efficient framing.

Attic Ventilation

1994 LTSGC 4.2.1

The Super Good Cents program may call for more ceiling or attic ventilation than your local code. If this is the case, let your framers and roofers know before they submit their bids. You may need to provide additional ventilating and baffling materials. See Chapter 4 for ceiling ventilation details.

THINGS TO DISCUSS WITH THE ELECTRICIAN

The electrical contractor needs to bid equipment that meets Super Good Cents appliance and control standards. In homes that include optional energy efficient lights, special light fixtures and luminaires must be installed.

Spot Ventilation Fans

1994 LTSGC 4.3.4

The Super Good Cents program requires a minimum 50 CFM of fan-powered exhaust in bathrooms and a minimum 100 CFM in kitchens. Some building codes allow operable windows to substitute for fans, but the Super Good Cents program doesn't. Make sure your electrician's bid includes fans for all bathrooms and kitchens. Ventilation in bathrooms can be reduced to 20 CFM and in kitchens to 25 CFM if spot ventilation is continuous.

If fan jacks are not in place, tell the electrician where they will be located so he or she can aim the fan outlet collar in the direction that provides the most direct route (shortest, with fewest elbows) to the fan jack location.

Whole House Fans

1994 LTSGC 4.3

In addition to spot ventilation, the Super Good Cents program requires whole house ventilation systems. This is a major departure from typical practice. The whole house exhaust fan can be remotely or surface mounted. Surface mounted whole house fans must have a sound rating of 1.5 sones or less for intermittent systems and 1 sone or less for continuous systems. When the electrician installs the fan, sound attenuating material must be placed between the fan supports and the framing. If fan jacks are not in place, tell the electrician where they will be located so he or she can aim the fan duct outlet collar in the direction that provides the most direct route (shortest, with fewest elbows) to the fan jack or termination device.

If an electrician has not wired a Super Good Cents house before, these requirements may be unfamiliar. The Super Good Cents representative can help clarify requirements and track down appropriate equipment. See Chapter 5 for details on ventilation systems.

Whole House Ventilation Controls

1994 LTSGC 4.3.6

Intermittently operated whole house ventilation systems are typically controlled by a 24-hour timer with a manual override switch. Your electrical contractor should include this timer in the bid. Heat recovery ventilation systems (air-to-air heat exchangers or exhaust air heat pumps) require specific controls. Be sure to get the equipment manufacturer's instructions to your electrician so he or she can bid the job right.

Some whole house ventilation systems are integrated with a forced air heating system. The electrical contractor may need to coordinate with the heating contractor for installation of any required control wiring, transformers, and relays.

Heading System Controls

1994 LTSGC 3.2

For central heating systems, low-voltage, heat-anticipating, micro processor controlled or electronic thermostats must be used. Zonal systems, such as baseboards and wall fan heaters, must use one heat-anticipating, micro processor controlled, or electronic thermostat per zone, mounted on a wall, not on the heater. Super Good Cents thermostats cost a little more, but are widely available and contribute significantly to comfort and energy savings.

Recessed Light Fixtures

1994 LTSGC 2.5

Recessed lighting fixtures in insulated cavities must meet two standards. Recessed lights must be IC (insulation cover) rated, so they can be in contact with insulation without creating a fire hazard. And they must have passed an air tightness test or be made airtight onsite. Be sure to let the electrical contractor know about recessed light requirements. There's more information in Chapter 5.

Efficient Interior Lighting Option

1994 LTSGC Appendix A, Chapter 4

If you're installing optional energy efficient indoor lighting, tell the electrical contractor about efficiency requirements for the general lighting fixture in the kitchen. Make sure the electrician is aware of the 2 watt/ft^2 kitchen lighting budget. See Chapter 5 for details.

Outdoor/Common Area Lighting Option

1994 LTSGC Appendix A, Chapter 4

If you're installing optional efficient exterior lighting, tell the electrical contractor what fixture types and controls you need. Lights must meet efficiency requirements or be controlled by motion sensors. See Chapter 5 for details.

THINGS TO DISCUSS WITH THE PLUMBER

Water Heater

1994 LTSGC 2.7

The Super Good Cents program requires water heaters that exceed federal minimum standards. You can get a list of approved water heater models from the Super Good Cents representative, so your plumber can choose an approved unit.

Any water heater on an uninsulated floor—including concrete slabs and platforms in garages—must sit on an R-10 pad. Make sure the plumber is aware of this requirement. It's a pain to correct if it's overlooked.

Exhaust Air Heat Pump Option

1994 LTSGC Appendix A 3.2

Typically, heating contractors install exhaust air heat pumps (EAHPs)—combination heat recovery ventilation/water heating systems. For some systems, the plumber must provide a water supply at the bottom of the tank, rather than at the top as is typical. The plumber also must install a condensate drain. Be sure your plumber and heating contractor coordinate to install this equipment. Chapter 6 includes information on EAHPs.

Air Leaks From Plumbing

Plumbing holes account for some of the biggest air leaks in most homes. Plumbers often do not carry materials with them for sealing plumbing penetrations. The air sealing person on your jobs should coordinate with the plumber. It is likely that the plumber is not familiar with the special air sealing techniques and materials shown in Chapter 6.

THINGS TO DISCUSS WITH THE HEATING CONTRACTOR

Ducts

1994 LTSGC 1.2 and 3.3

Metal duct must be insulated with at least R-11 insulation. This includes supply plenums or other ducts that run through slabs. Flexible duct and duct board systems must be insulated to at least R-8. Super Good Cents duct insulation levels are higher than most codes require. Make the heating contractor aware of these requirements before bidding the job.

Super Good Cents specifications also require air sealing supply and return ducts, air handler cabinets and plenums, inside and outside heated space, at all joints, and corners. Air sealing requirements far exceed any current building code. Check Chapter 7 for details.

Controls

1994 LTSGC 3.2

All thermostats must be either micro processor or electronically controlled or have a heat anticipation feature. See Chapter 7 for details. Make your heating contractor aware of special control requirements.

Ventilation Systems

All Super Good Cents homes must have whole house ventilation systems. Often, the heating contractor is involved in installing the system. The most common cases requiring careful coordination with the heating contractor are:

1. When you use a remotely mounted exhaust system ducted to several locations in the house - It may be a complete ventilation system sold for that purpose, or a system with a high quality fan and other parts assembled for the purpose.
2. When you use a whole house ventilation system that supplies fresh air through heating/cooling system ducts.
3. When you use air-to-air heat exchangers - They're often installed by heating contractors familiar with quality duct installation and balancing airflows. Special equipment efficiency standards apply. Consult the equipment manufacturer's installation instructions.
4. When you use exhaust air heat pumps - They're usually installed by heating contractors familiar with quality duct installation and refrigeration equipment. Consult the equipment manufacturer's installation instructions.

See Chapter 7 for more information on these topics.

Room Pressure Relief/Distributed Returns

Many homes with forced air heating systems have one central return grill serving all the supply registers. Many homes with forced air heating also contain naturally vented combustion appliances. When people close interior doors, supply air delivered to the closed room cannot get back to the central return grill. The return grill becomes "starved for air," and air pressures in the return zone go "negative." If the combustion appliance is in the return zone and the return zone goes "negative," odors or combustion gasses can be pulled into the home.

In addition, if the heating contractor doesn't seal ducts well, supply side duct leakage can create negative pressure inside the home. Negative pressure can induce spillage from naturally vented combustion appliances.

If your home will have forced air heat and naturally vented combustion appliances, avoid spillage potential by carefully sealing ducts as they are installed. Passive grills or distributed returns in each room with a supply are ways to avoid negative pressures caused by door closure.

INSTALLING COMBUSTION APPLIANCES

1994 LTSGC 2.6

Combustion appliances include fireplaces, wood stoves, combustion furnaces, auxiliary heaters for heat pumps, combustion water heaters, gas clothes dryers, and gas cooktops. Some utilities restrict combustion devices in Super Good Cents homes; others do not.

The Super Good Cents program includes requirements for outside combustion air and venting that slightly exceed most building code requirements. Before you have combustion devices installed, make sure specific models meet requirements covered in Chapter 8, and be sure installers are aware of combustion air requirements.

All new homes are tighter than they used to be. Combustion appliances in tight homes can be extremely sensitive to negative pressure environments created by exhaust-only ventilation devices in the home. Kitchen range hood fans and dryers tend to be the strongest exhaust-only ventilators, but bath fans and any other device that pulls air out of a home can make it more difficult for a naturally vented, solid fuel appliance to sustain strong draft.

From a health and safety standpoint, it is recommended, but not required, that balanced ventilation systems such as air-to-air heat exchangers—as opposed to exhaust-only systems—be used for whole house as well as spot ventilation in homes with combustion devices. Typical ventilation in Super Good Cents homes currently consists of a balanced whole house system and unbalanced, exhaust-only spot ventilation.

For a discussion of interactions between mechanical systems and combustion appliances in homes, order the Reliable Chimney Venting Training Manual by John Gulland from Hearth Education Foundation, 3019 Perry Lane, Austin, TX 78731; 512-450-0987.

For information about balanced central ventilation systems, see the "Heat Recovery Ventilation" section of Chapter 7 in this guide, or order "Air-to-Air Heat Exchanger Systems: Marketing, Design and Installation," a two-part training videotape and study guide, from Oregon State University Extension Energy Program, Batcheller Hall 344, Corvallis, OR 97331-2405; 503-737-3004.

For information about house pressure tests that verify whether systems are balanced, contact your participating Super Good Cents utility or state technical assistance provider.

PREVENTING AIR LEAKAGE

1994 LTSGC 2.3.1 and 2.3.2; Appendix A, Chapter 2 and 3.3

Chapter 9 is titled "Air Tightening Specialist," a trade that doesn't even exist in many locales. The best quality control in air sealing occurs when a single person is responsible (rather than when each trade seals its own leaks) and develops expertise by doing air sealing at each job site.

The air tightening specialist could come from a number of trades, including carpenters, insulation contractors (some are adding air sealing to their services), and even general contractors. An important advantage of having one person in charge of all air sealing is that you get a better handle on costs for time and materials.

The Super Good Cents program gives you a choice between Standard Air Leakage Control (extensive caulking and sealing of air leaks somewhat tighter than typical construction) or Advanced Air Leakage Control (a very tight house with a "continuous air barrier").

Advanced Air Leakage Control can be used in the Super Good Cents program in two ways:

1. As a program option. The house must qualify using Standard Air Leakage Control. Adding Advanced Air Leakage Control measures and passing a blower door test satisfy the optional requirements.
2. To help qualify the house for the Super Good Cents program - It may be less expensive to install Advanced Air Leakage Control measures than other energy conservation measures. When using Advanced Air Leakage Control to qualify the house, you need to pass a blower door test. See Chapter 9.

If you have an experienced air tightening specialist, Advanced Air Leakage Control often isn't a big stretch. It could save you money compared to other measures. Chapter 9 includes details on both Standard and Advanced Air Leakage Control.

THINGS TO DISCUSS WITH THE INSULATION CONTRACTOR

1994 LTSGC 1.2

Compared to homes built to code minimum, the Super Good Cents program requires higher insulation levels, different insulation details for advanced framing, and better quality control. These factors affect the insulation contractor's cost. Go over requirements before contractors bid on the job. Chapter 10 covers these issues in detail.

Quality Control

Super Good Cents specifications call for minimizing compression and voids in insulation. Minimizing compression requires careful cutting and fitting of insulation. Super Good Cents representatives look for quality installation when they visit the site. Make sure the insulation contractor understands this before bidding.

Floor Insulation

Most Super Good Cents homes have at least R-30 underfloor insulation. This makes floors with shallow framing cavities more difficult to insulate. In general the idea is to match the floor framing cavity to the depth of the insulation batt. See Chapter 10. I-beam floor cavities are wider than cavities created with dimension lumber, so I-beam floors require special "full width" batts to fill the space. Regular width batts in I-beam floors leave a gap at each edge and do not provide a true dead air space below the floor.

Discuss with the insulation contractor who will supply the floor vapor retarder and crawl space ground cover. That way the insulation contractor will know whether to include these materials in the bid.

Wall Insulation

If you qualified the house using advanced wall framing (see Chapter 4), let your insulator know you're using 24-inch on center framing. Otherwise the insulator may show up onsite with the wrong size batts. (Obviously, this isn't a worry if you're using a blown in material.) If you're using rigid insulation on either side of wall framing, be clear about which subcontractor will install it.

If the insulation subcontractor is going to supply the vapor retarder (either attached to the insulation or separate), make that part of the bid.

Specify that insulation must be cut to fit around obstacles in walls, such as wires, electrical boxes, and plumbing.

Recessed fixtures on exterior walls, such as electrical panels and medicine cabinets, must have 2 inches of rigid insulation behind them. Depending on scheduling, if the insulation contractor doesn't have access (or if you haven't told the contractor that the material will be needed onsite), you may be responsible for providing this insulation.

If your insulation subcontractor is using wet or damp spray materials, they need time to dry before drywalling. Find out about required drying time.

Ceiling Insulation

If you're building an advanced frame ceiling (see Chapters 4 and 10), you may want to talk to your insulation contractor to see if you can save money by using high R-value per inch insulation at the ceiling perimeter instead of advanced frame trusses. High R-value foam baffles may be less expensive than special trusses. You might want to get bids both ways.

Be sure to discuss who's supplying the ceiling vapor retarder.

THINGS TO DISCUSS WITH THE DRYWALL CONTRACTOR

Here are a few things the drywaller needs to know before making a bid:

1. If faced insulation will be used, flanges may be stapled to the face of the studs. This can increase labor for the drywaller.
2. If there are polyethylene vapor retarders (or air barriers), extra care must be taken during drywall installation to avoid damaging them. Also, drywall can't be glued over polyethylene. During cold weather, polyethylene vapor retarders in ceilings should be insulated before taping and texturing. Otherwise, moisture may condense in ceiling drywall, causing extensive moisture damage. See Chapter 11.
3. If you're doing Advanced Air Leakage Control (see Chapter 9), the drywaller must take care to avoid damaging gaskets, sealant applications, and polyethylene sheets.
4. If your insulation subcontractor is using wet spray materials, they may need time to dry before drywalling. Schedule accordingly.
5. With R-49 ceiling insulation typical in Super Good Cents homes, you should specify 5/8-inch ceiling drywall.

THINGS TO DISCUSS WITH THE PAINTERS

The painting contractor doesn't have much impact on the home's energy performance. However, if the painter applies vapor retarder paint as a drywall sealer, the insulation contractor can use less expensive unfaced batts. See Chapter 12 for details on this cost saver.

Chapter 3

General Contractor

When Super Good Cents homes have concrete structural elements, the concrete contractor is responsible for meeting key insulation, moisture protection, and ventilation requirements that affect the home's thermal performance, long-term durability, and indoor air quality.

CRAWL SPACE STEM WALL VENTILATION

1994 LTSGC 4.2.2

Vents in stem walls help keep floor insulation and floor framing dry. In areas with radon problems, crawl space vents reduce the potential for radon buildup under the floor and radon entry into the house.

Most building codes require crawl space ventilation—typically 1 ft^2 per 150 ft^2 of crawl space. You need to meet Super Good Cents program minimums even if your locality does not have ventilation requirements.

How Many Vents?

Vents are rated in terms of their "net free area": the open area through which air can flow. Since air does not flow through the vent frame, louvers, and wire mesh, net free area is always less than overall area of the vent.

Manufacturers typically stamp net free area on vents. If the vent manufacturer does not provide information on net free area, assume that it is about half of the overall vent area.

Super Good Cents specifications require 1 ft^2 net free area of vent for each 150 ft^2 of crawl space floor. When allowed by local building officials, area may be reduced to 1 ft^2 net free area for each 300 ft^2 of crawl space floor if the soil is dry and the crawl space is well drained.

Example 1:

The crawl space area of a home is 1,400 ft^2. How many ft^2 of crawl space venting do you need to meet Super Good Cents specifications?

1,400 ft^2/150 = 9 ft^2 net free vent area

If the vent provides 1 ft^2 net free area per vent, you need 9 ft^2/1 ft^2 = 9 vents.

If the vent provides 0.8 ft^2 net free area per vent, you need 9 ft^2/0.8 ft^2 = 11 vents.

Example 2:

If the building official allows you to use 1 ft^2 of venting per 300 ft^2 of crawl space, how many ft^2 of venting do you need for the 1,400 ft^2 house in Example 1?

1,400 ft^2/300 = 5 ft^2 net free vent area

Vent Placement

Place vents at opposing points on the stem wall for good cross ventilation (preferably at all four comers of the crawl space).

Some vents come with plastic foam plugs. They help keep the crawl space warmer in winter. Others come with closeable flaps. If you use closeable vents, place the plugs or flap control levers on the outside of the stem wall so they may be opened or closed without having to crawl under the floor.

Energy efficient homes may have 9 to 10 inches of insulation beneath the floor. Think ahead. Where possible, place vents low enough in the stem wall so they will not be blocked by floor insulation. However, vents must be above finish grade level. The insulation contractor must baffle vents if they are not below the floor insulation level.

Figure 3A shows a plan view of a crawl space with vents providing good cross ventilation. The section drawing shows vent placement below floor insulation level.

SLAB ON GRADE

Insulation Requirements

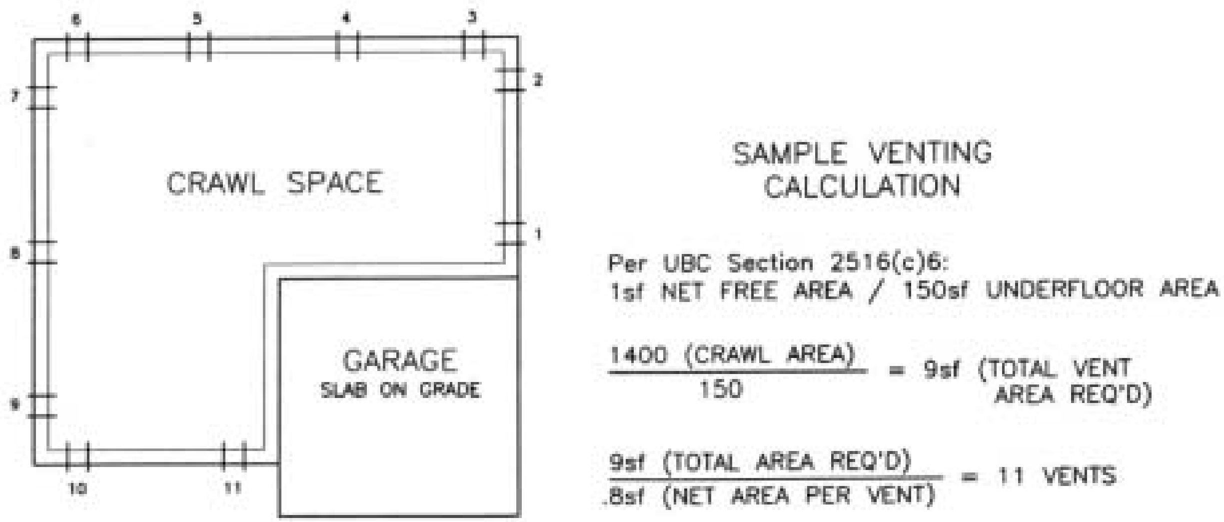
1994 USGC 2.1.8 and 4.1.2; Reference 3, Appendix A, Chapter 5

Figures 3B through 3H show approaches to slab construction and perimeter insulation. All slabs in heated spaces must be insulated at their perimeters. Typically, a minimum 24 inches of R-15 insulation is placed vertically or vertically and horizontally at the slab edge.

Slabs containing radiant heating systems are an exception. Radiant slabs must have R-15 at the perimeter and R-10 below the remainder of the slab.

Monolithic slabs must be insulated a minimum of 24 inches from the top of the slab to the bottom of the thickened edge. Three inches of polystyrene insulation, R-15, exceeds many local energy codes.

Figure 3A
CRAWL SPACE VENTILATION



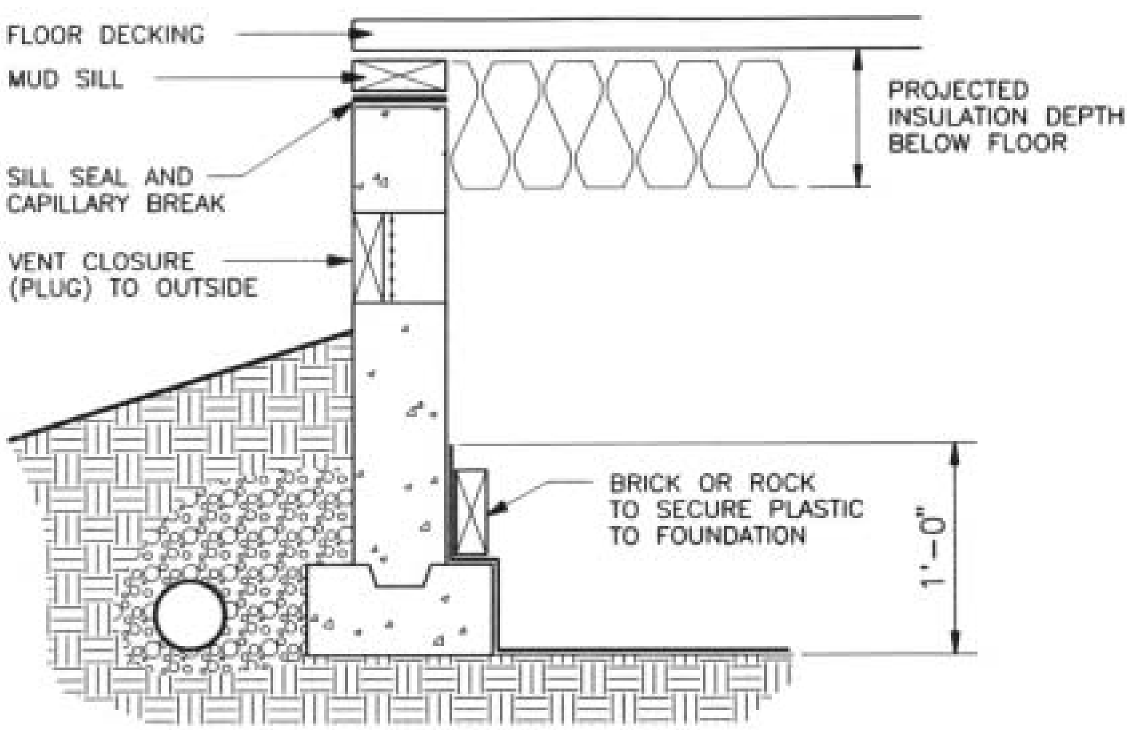
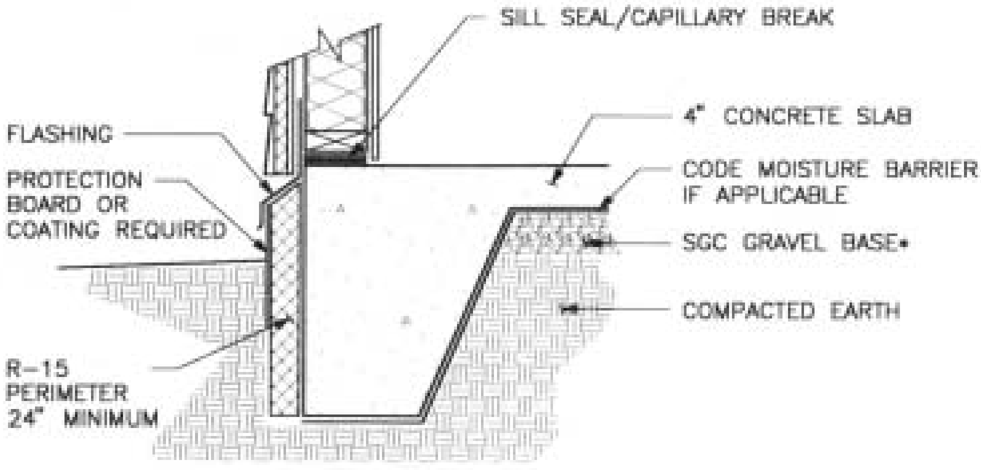
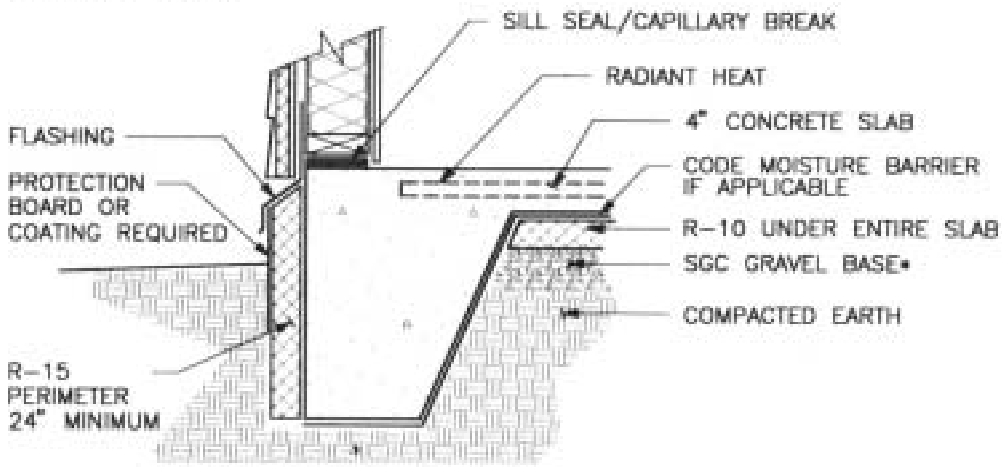


Figure 3B
MONOLITHIC SLAB INSULATION

TYPICAL SLAB

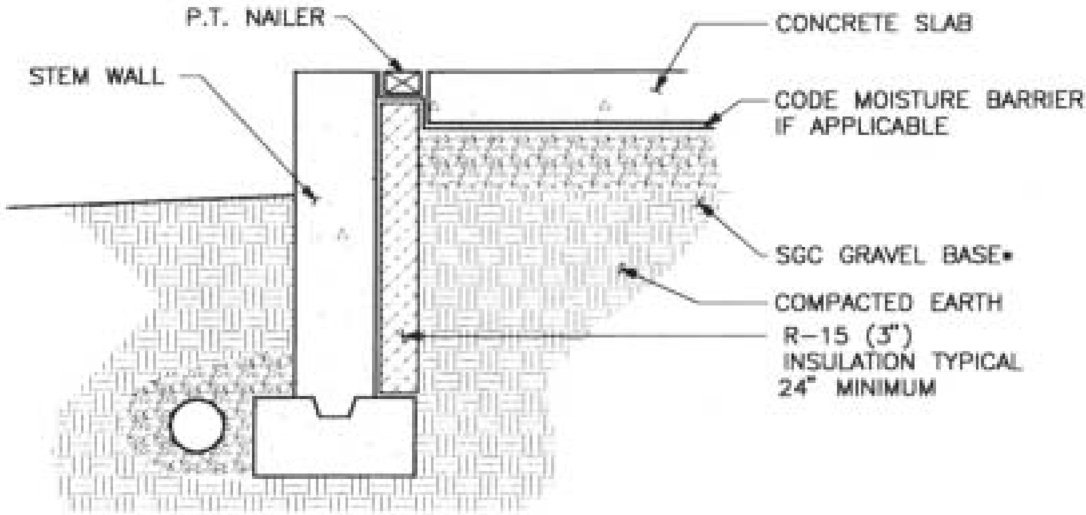


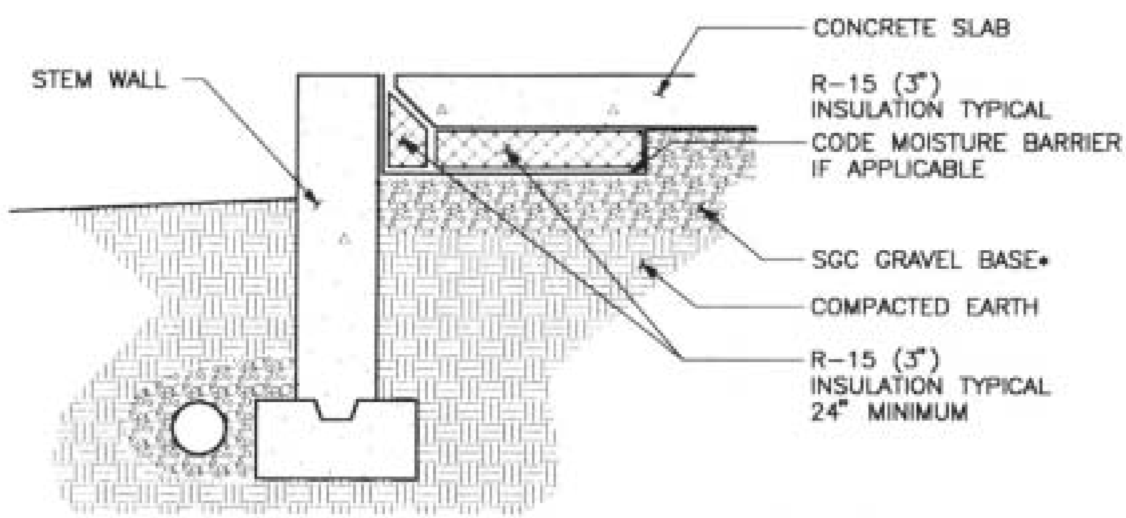
RADIANT SLAB



*SEE 1994 LONG-TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

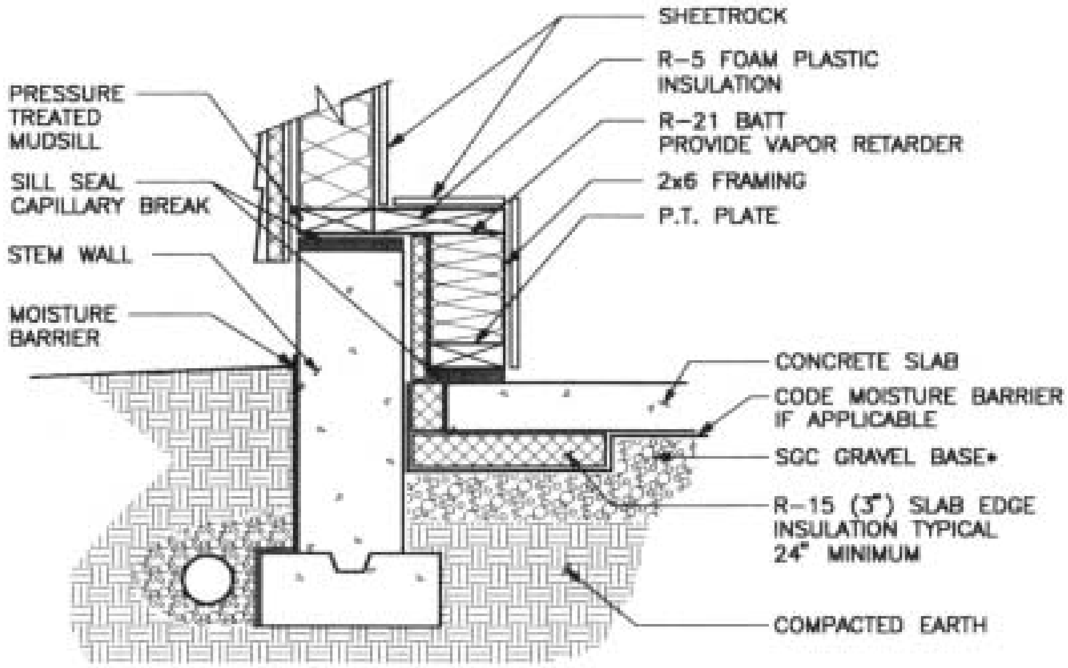
Figure 3C
FLOATING SLAB ON GRADE
WITH INTERIOR PERIMETER INSULATION

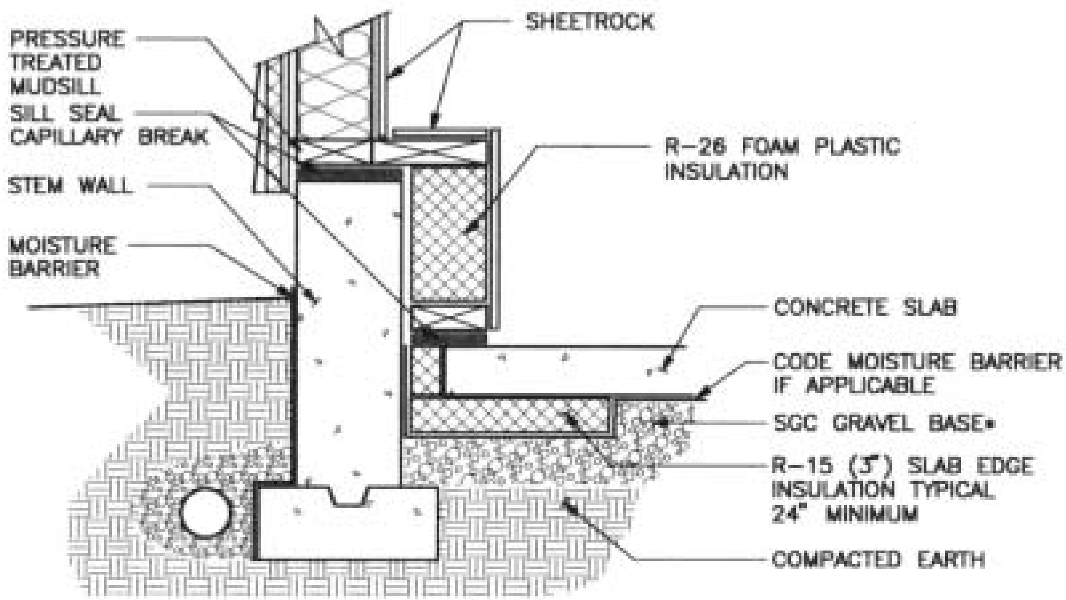




*SEE 1994 LONG-TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

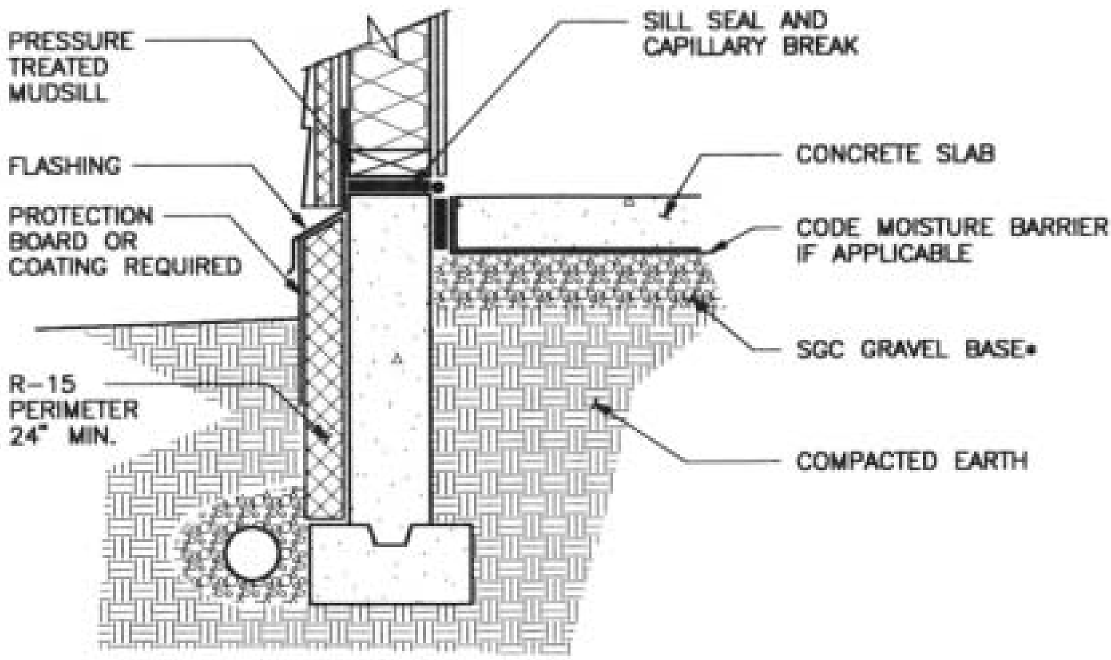
Figure 3D
FLOATING SLAB/STUB WALL INSULATION OPTIONS





*SEE 1994 LONG-TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

Figure 3E
FLOATING SLAB ON GRADE
WITH EXTERIOR PERIMETER INSULATION



*SEE 1994 LONG-TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

Figure 3F

INSULATION BETWEEN SLABS IN HEATED AND UNHEATED SPACES

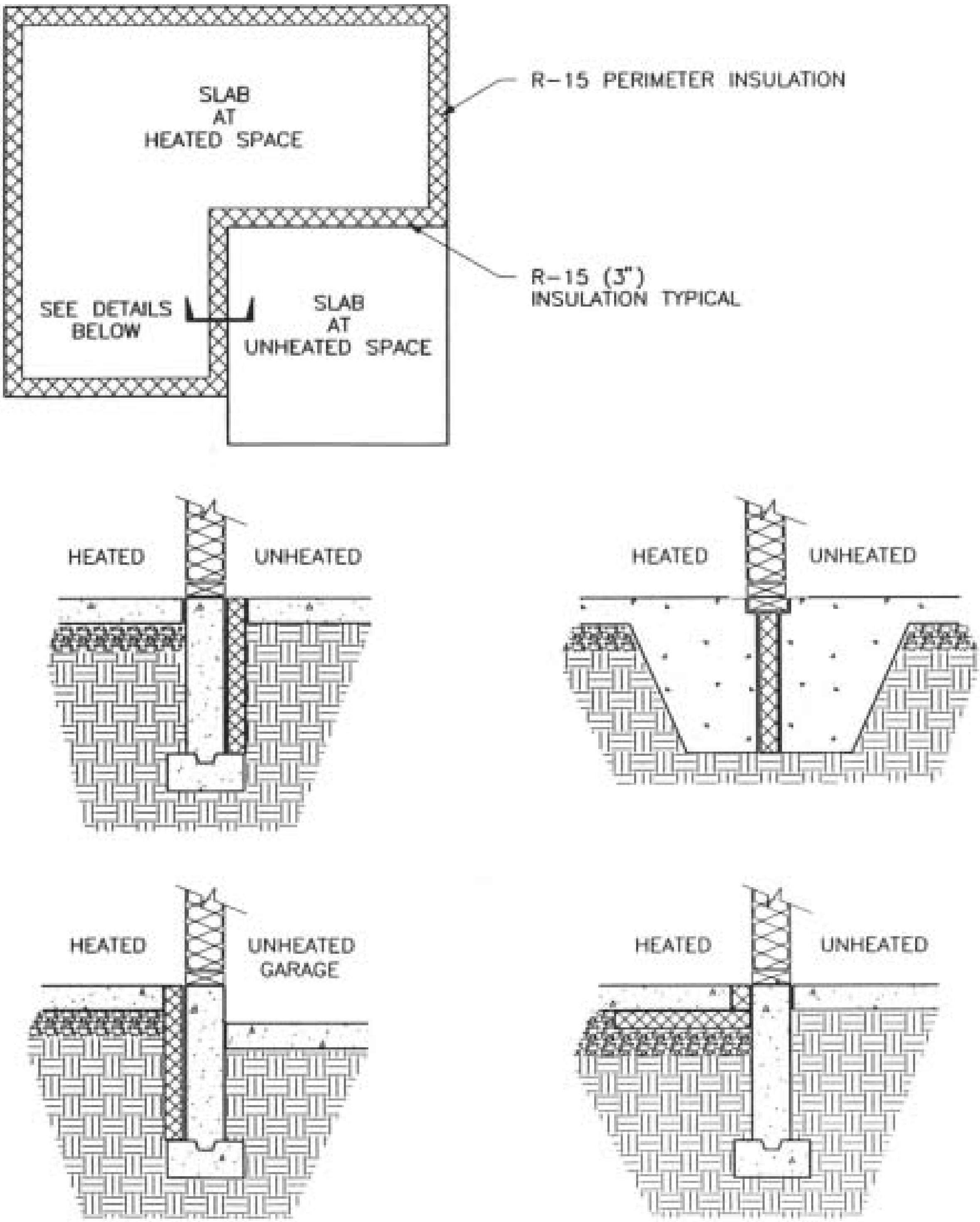


Figure 3G
INSULATION BETWEEN SLABS AND CRAWL SPACES

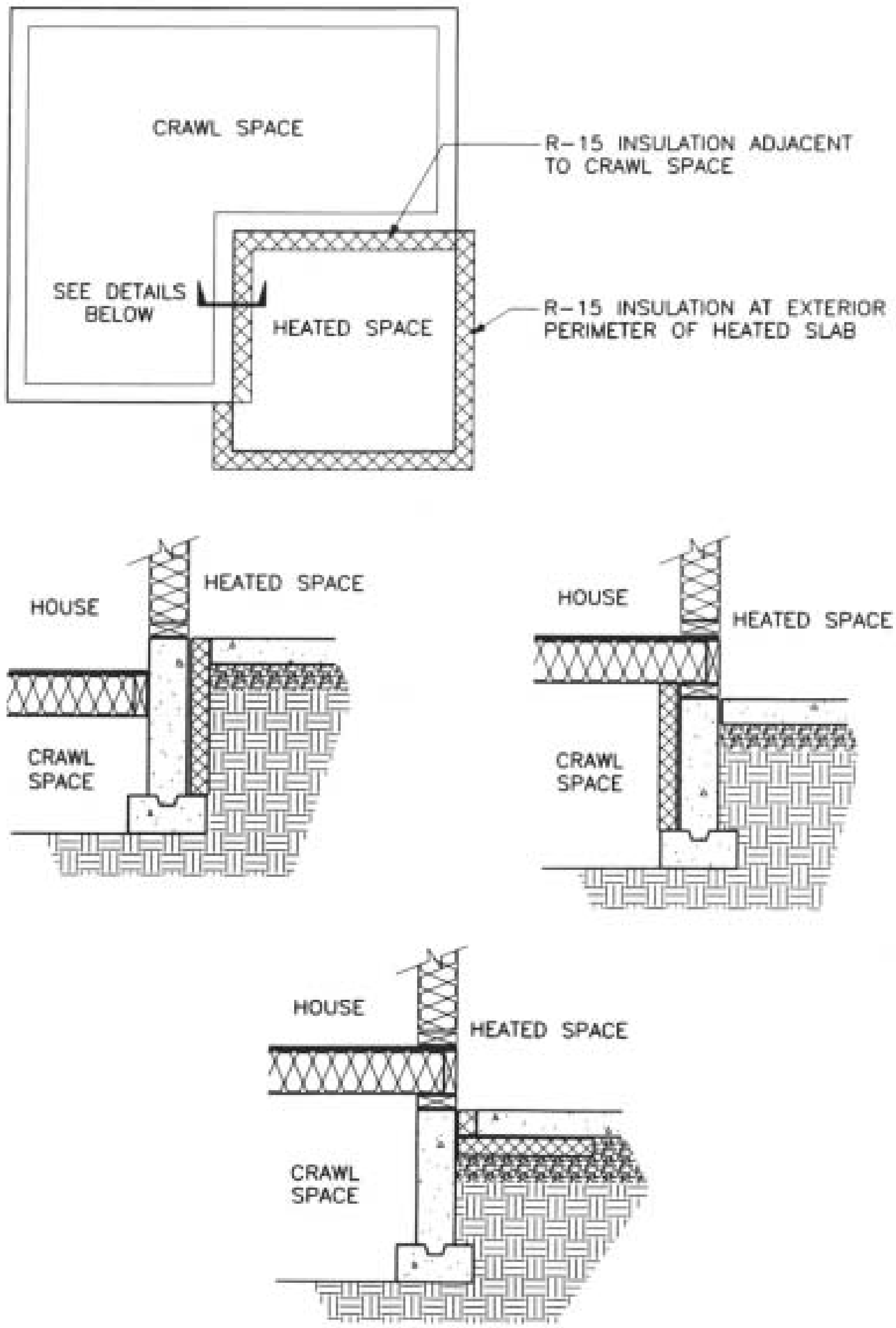
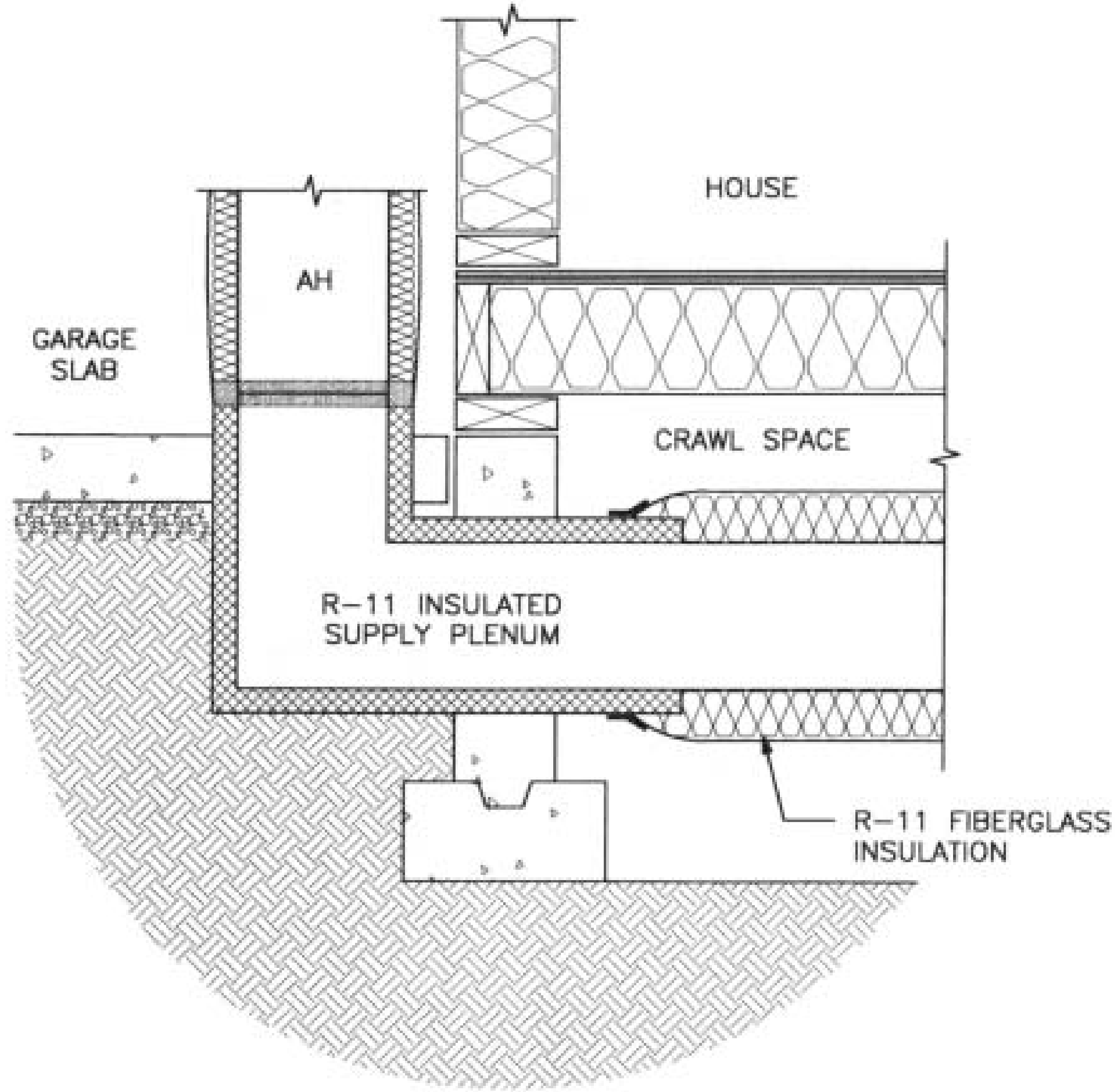


Figure 3H
INSULATED SUPPLY PLENUM IN GARAGE SLAB



If you are making a hole in the garage slab for the furnace supply plenum, make sure the hole can accommodate the supply plenum and R-11 (2 to 2-1/2 inches rigid foam) insulation on all sides. See Figure 3H. Verify hole dimensions with the heating contractor.

Floating slabs must be insulated from the top of the slab vertically for a distance of 24 inches, or to the bottom of the slab and then horizontally for a total of 24 inches. The general contractor may want you to supply a nailable surface (such as a pressure treated lx) on top of the insulation for attaching carpet or other floor finish material. Be sure to talk over your approach to this detail before you finalize your bid.

It is important to keep in mind the exact locations of heated slab edges. If a kitchen or family room slab is next to a garage slab, for example, there must be full insulation between the two slab areas. Another slab edge that can be overlooked is where slabs are adjacent to crawl spaces. Figures 3F and 3G show possible insulation details for these areas.

The utility representative needs to see the insulation before it is covered.

Full Sub-Slab Insulation Option

As an option, builders may insulate the entire area under the slab. For slab on grade, R-15 perimeter insulation is installed as usual. Below grade slabs must have an R-5 minimum thermal break from all piers and footings with ground contact and from slabs in unheated spaces. The underslab insulation is either R-5 in Climate Zone 1 (typically 1-inch-thick foam) or R-10 in Climate Zones 2 and 3 (2-inch-thick foam).

Below grade slab insulation must be continuous under the slab. Place insulation over gravel and cover insulation with a minimum of 2 inches of sand.

Sub-Slab Gravel Requirements

1994 LTSGC 4.1.2

Super Good Cents requires a gravel base under slabs in heated spaces to provide a capillary break from ground moisture. If radon is a problem where you build, the gravel base has an additional side benefit: In the event radon is detected in a home, the gravel base can be ventilated to remove radon.

The gravel base course must be at least 4 inches deep. Gravel must meet one of the following standards:

1. ASTM Standard C33, “Standard Specifications for Concrete Aggregates.” Gravel shall be size #67 or larger.

2. 1988 Washington State Department of Transportation specification 9-03.1(3), "Coarse Aggregate for Portland Cement Concrete." Gravel shall be of Grade 5 or larger.
3. Gravel must be screened, washed, and free of deleterious substances in a manner consistent with ASTM C33, with 100 percent of the gravel passing a 1-inch sieve and less than 2 percent passing a #4 sieve. Sieve characteristics shall conform to those acceptable under ASTM C33.

Your supplier is likely to be familiar with one or more of these standards. Using gravel that meets these requirements ensures a good capillary break and allows effective ventilation if necessary to reduce radon levels.

Although not required by the Super Good Cents program, radon entry can be further reduced by sealing cracks and joints in slabs and below grade walls. Use sealants designed for use with concrete, and follow manufacturer's application instructions.

The ground moisture barrier that most building codes require under slabs also helps reduce radon passage. The moisture barrier works best for radon protection when it is immediately below the slab. Local code may require the moisture barrier to be located there.

Some contractors are reluctant to pour concrete directly over a moisture barrier. They are worried about cracking caused by trapped excess water. To minimize cracking, use low-slump concrete with no excess water and plasticizing additives that allow low-slump concrete to flow. Plasticizers are mixed at the plant by special order.

Carefully curing concrete also minimizes cracking. The slab cures best if its top and bottom have nearly equal moisture content. Keep the top of the slab wet for several days. Or paint a curing agent onto the slab after the finish troweling. The curing seal helps keep moisture content uniform throughout the slab.

A helpful publication on this subject is Recommended Practice for Concrete Floor and Slab Construction, from the American Concrete Institute, Box 19150, Redford Station, Detroit, MI 48219.

If you install a sand base over the moisture barrier and radon is a concern, minimize radon passage by sealing seams, gaps, holes, and tears in the barrier before you place the sand.

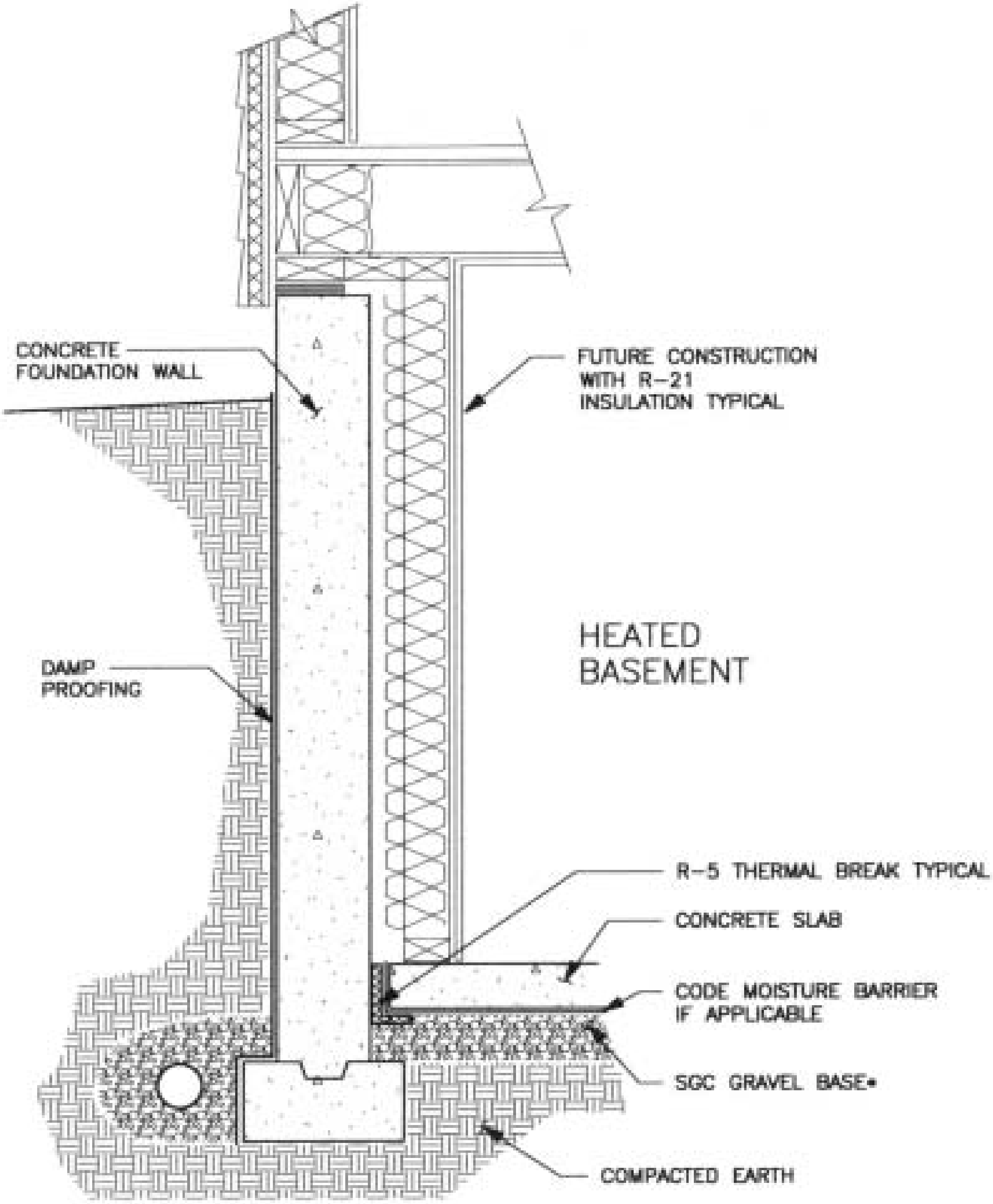
BELOW GRADE CONSTRUCTION

Insulation Requirements

1994 LTSGC 7.1.6

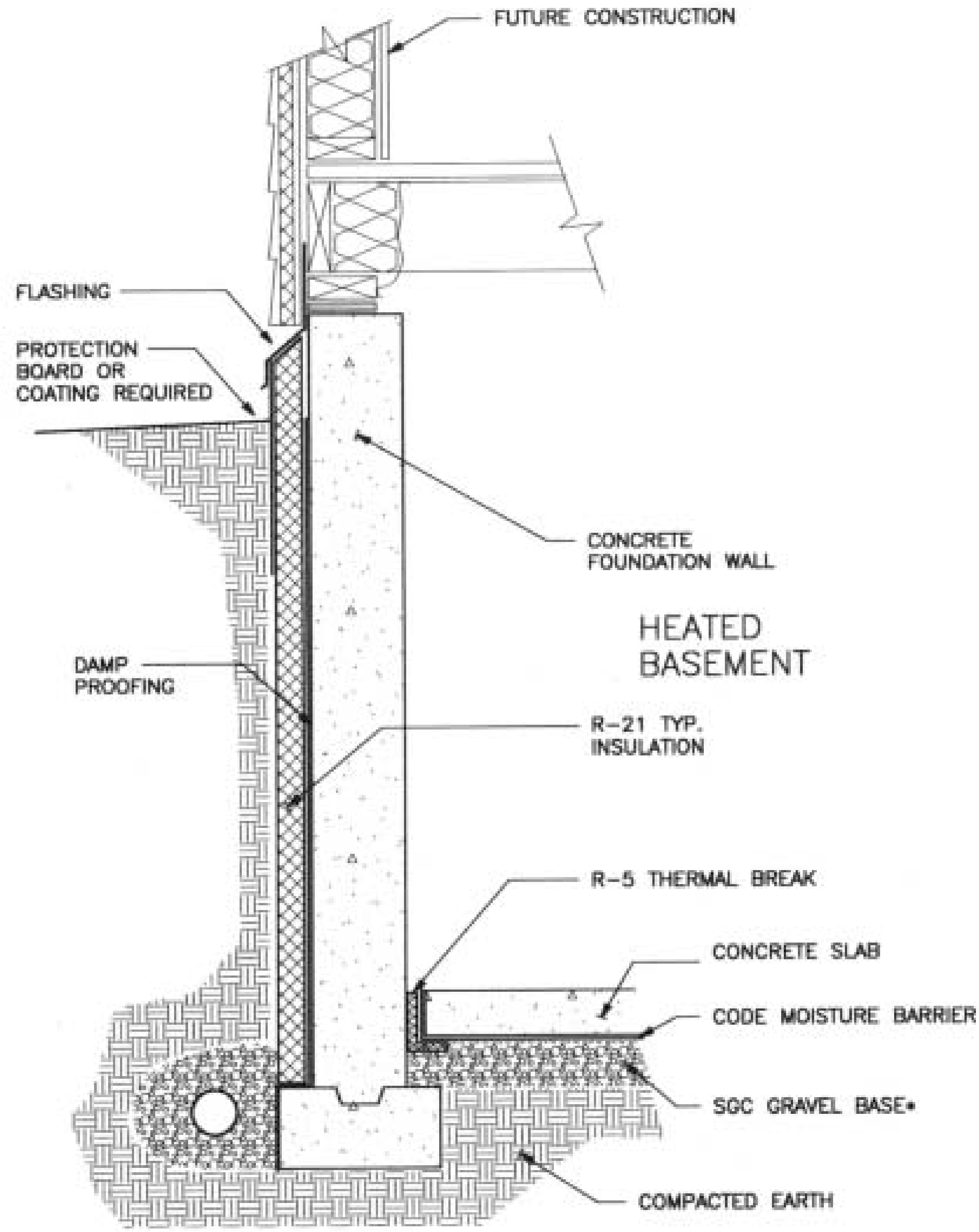
Exterior insulation of basement walls may fall within the scope of concrete work. Insulate the entire below grade wall after you apply damp proofing. Figures 31 through 3K show below grade wall insulation options.

Figure 3I
BELOW GRADE WALL WITH INTERIOR INSULATION



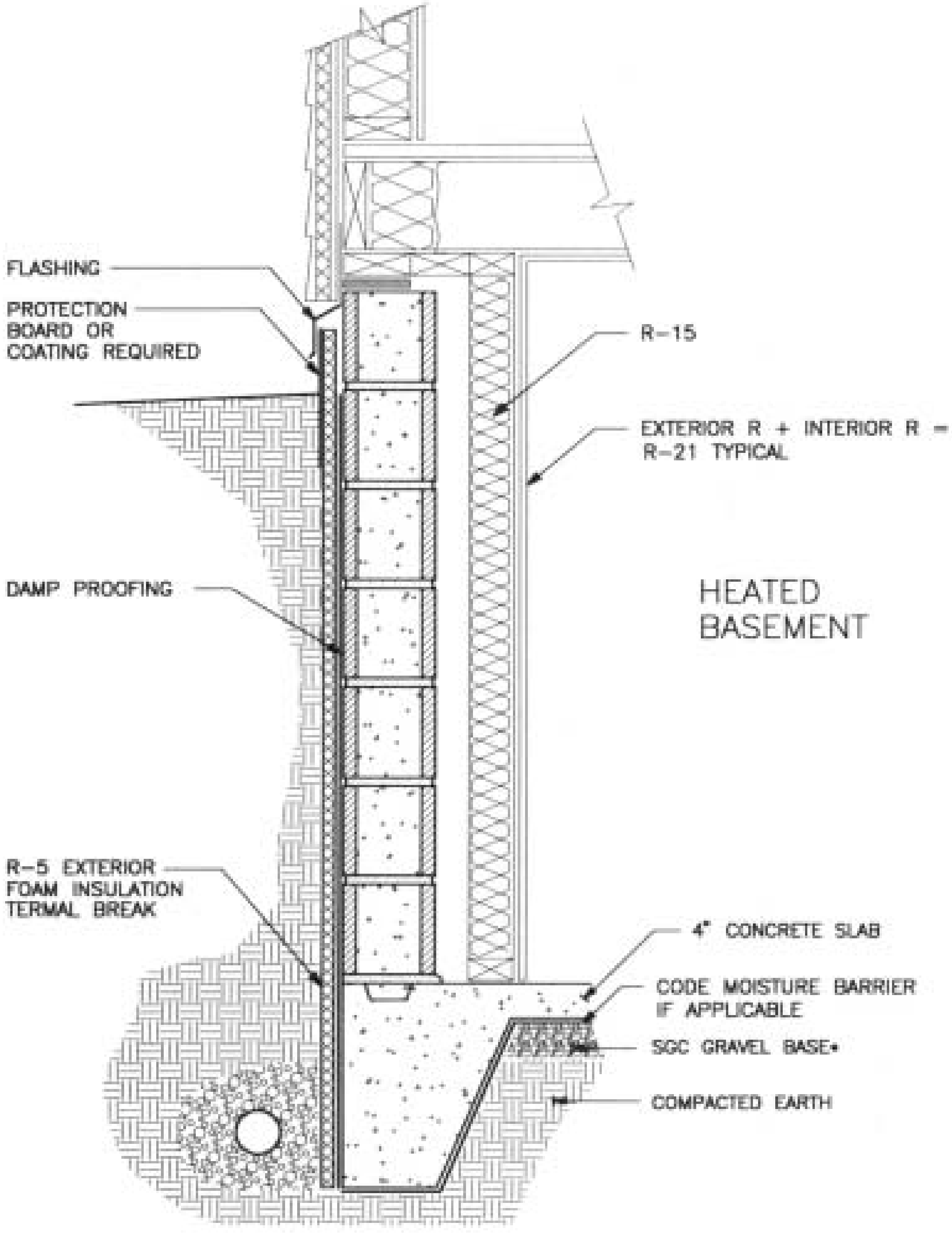
*SEE 1994 LONG TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

Figure 3J
BELOW GRADE WALL WITH EXTERIOR INSULATION



*SEE 1994 LONG TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

Figure 3K
BELOW GRADE MONOLITHIC SLAB WITH BELOW GRADE BLOCK WALL: COMNATION INTERIOR AND EXTERIOR INSULATION



*SEE 1994 LONG TERM SUPER GOOD CENTS TECHNICAL SPECIFICATIONS 4.1.2 FOR APPROPRIATE AGGREGATE STANDARDS.

Chapter 4
Framing Crew

SPECIAL MATERIALS FOR FRAMING

A number of Super Good Cents materials specifications affect the framer. The program requires low formaldehyde ratings for structural panels such as plywood and oriented strand board. In some homes, 24-inch on center framing requires structural sheathing that is span-rated for 24 inches on center. Some houses may require special trusses or exterior insulating sheathing. When you are bidding on a Super Good Cents house, check with the general contractor so you can anticipate these special requirements.

You also may be installing new attic ventilation products, special exhaust fan jacks that are actually close to exhaust fans, and through-the-wall fresh air inlets.

ENERGY EFFICIENT FLOOR FRAMING

Joisted Floor Systems

Deeper joists, longer spans, and fewer beam runs under the floor make floor construction easier and quicker for the framer. Joisted floors are easier to insulate too.

Sheathing (stamped “Exterior,” “Exposure 1,” or “HUD-Approved”) over the joists usually provides the 1-perm vapor retarder that is required to protect floor insulation from indoor moisture. Sheathing also makes it easier to control air leakage through the floor, compared to a floor built with decking.

Post and Beam Floors

Post and beam floors with decking subfloors are acceptable, but their energy performance often is inferior to joisted floor systems. It is harder and more costly to install thick insulation below decking floors. Since 2x decking shrinks, it is difficult to control air leakage through the floor. Because decking has no perm rating, a separate vapor retarder must be installed to protect floor insulation from indoor moisture. Some post and beam floor systems use plywood or other manufactured wood panels as the subfloor, rather than 2x decking. These materials greatly reduce air leakage through the floor. They may act as a vapor retarder too.

Air Sealing at Floor Framing

Figures 4A and 4B show framing and insulation details for floor systems. They also show air sealing at the rim or floor perimeter that can be done best during floor framing. Seal air leaks above and below the mudsill when using post and beam floors.

If the house uses the Advanced Air Leakage option (see Chapter 9), the floor must have a continuous air barrier. If the home has a sheathing subfloor, you can turn the sheathing into an air barrier by gluing all edges of the sheathing as it is installed. See Figure 4C. If the house has a 2x decking subfloor, install a separate air barrier, such as continuous polyethylene, above the decking. See Figure 4B.

FRAMING BASEMENT WALLS

R-21 wall insulation is typical for heated basements. Below grade, you can use 2x4s—just hold them out at least 2 inches from foundation walls. That way you will provide a minimum of 5-1/2 inches of space for insulation. See Figure 4D.

TIP: An additional inch allows an air space between the insulation and the foundation wall. That reduces the risk of dampness penetrating from the foundation wall to the insulation.

In many cases, concrete walls are half height, with framed walls above. Figure 3D in Chapter 3 shows two methods for insulating short concrete walls. Both leave a ledge at about half wall height. Another option is to frame the inside wall all the way up to the floor above. That way you leave room for two layers of wall insulation.

ADVANCED AND INTERMEDIATE WALL FRAMING

Since insulation has a higher R-value than wood, reducing wood and replacing it with insulation reduces heat loss. In a typical standard frame wall, 23 percent is wood, and 77 percent is insulated cavity. The "intermediate" frame accounts for 22 percent of the wall area, leaving 78 percent for cavity insulation. The "advanced" frame wall is approximately 17 percent wood and 83 percent insulated cavity. Advanced frame walls have about 25 percent less wood than standard frame walls.

Advanced or intermediate wall framing help homes qualify for the Super Good Cents program. Figure 4E shows that the main difference between a standard and advanced frame is the reduced amount of wood in the wall.

Advanced and Intermediate Framing Features

If approved plans indicate that the home must have advanced or intermediate framing to qualify for the Super Good Cents program, the utility representative looks for the following framing features:

Figure 4A
JOISTED FLOOR

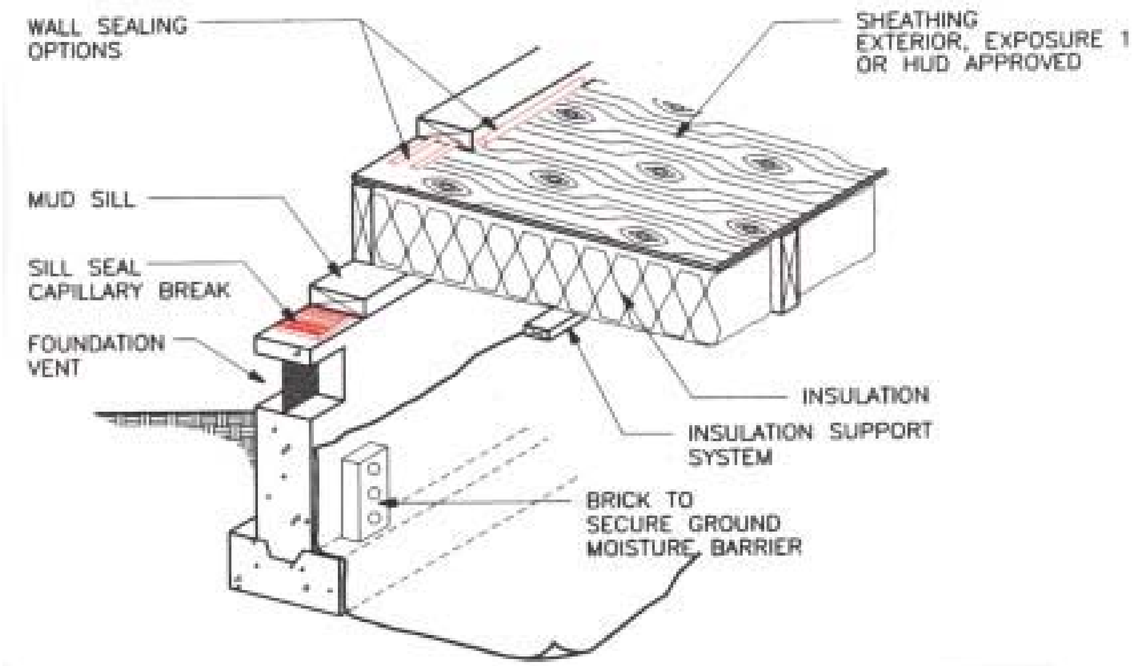


Figure 4B
POST AND BEAM FLOOR WITH DECKING SUBFLOOR

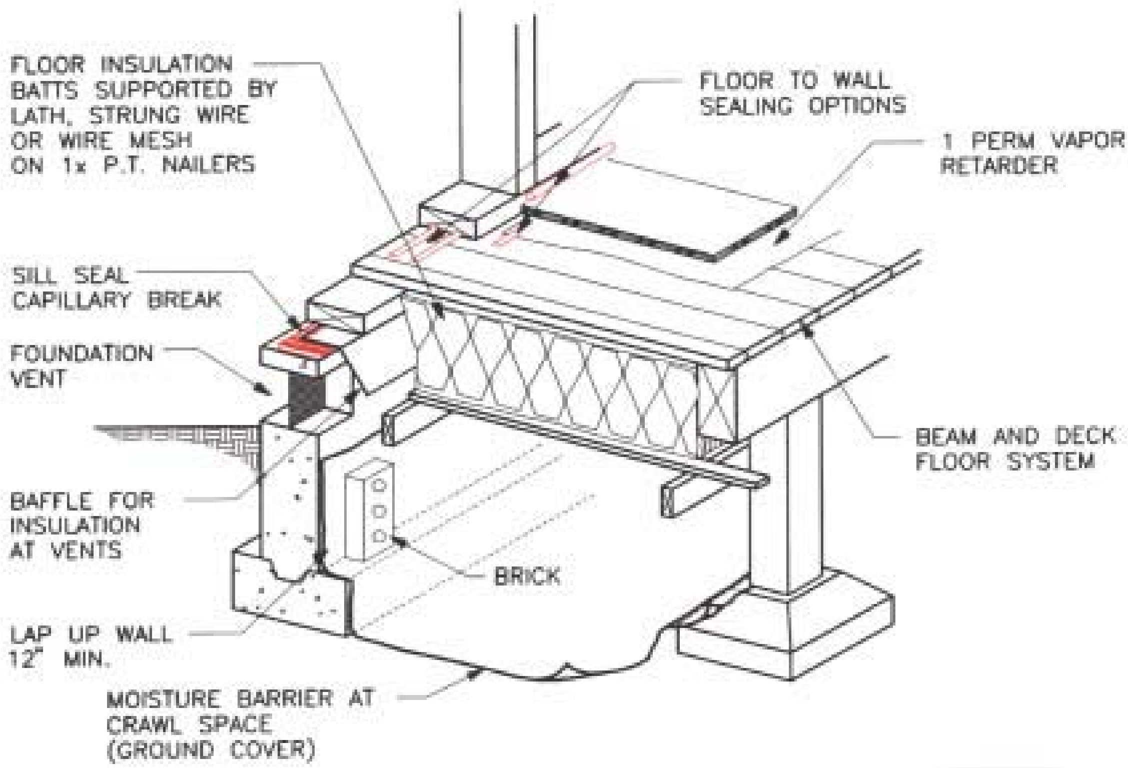


Figure 4C
FLOOR SHEATHING AIR BARRIER

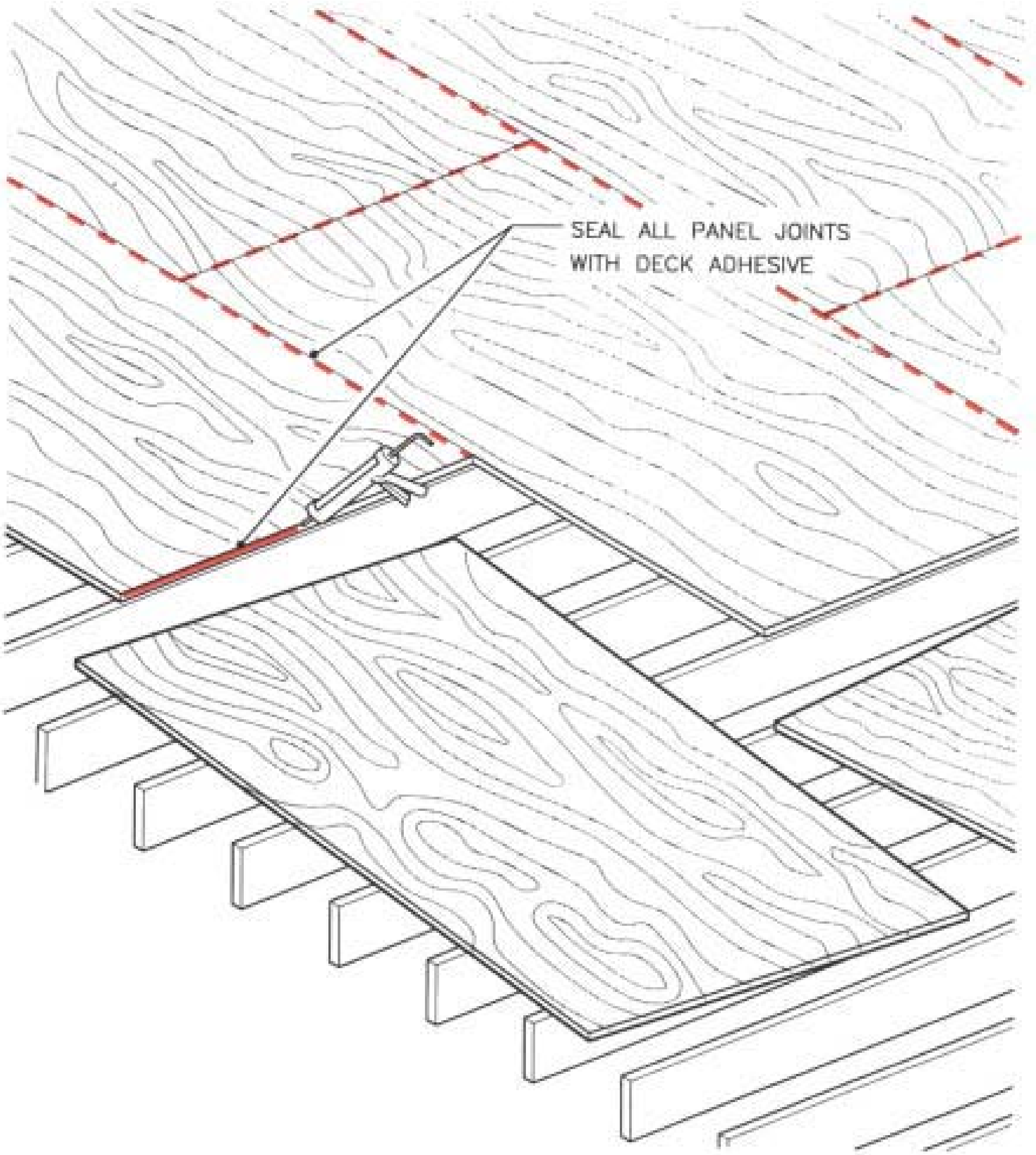
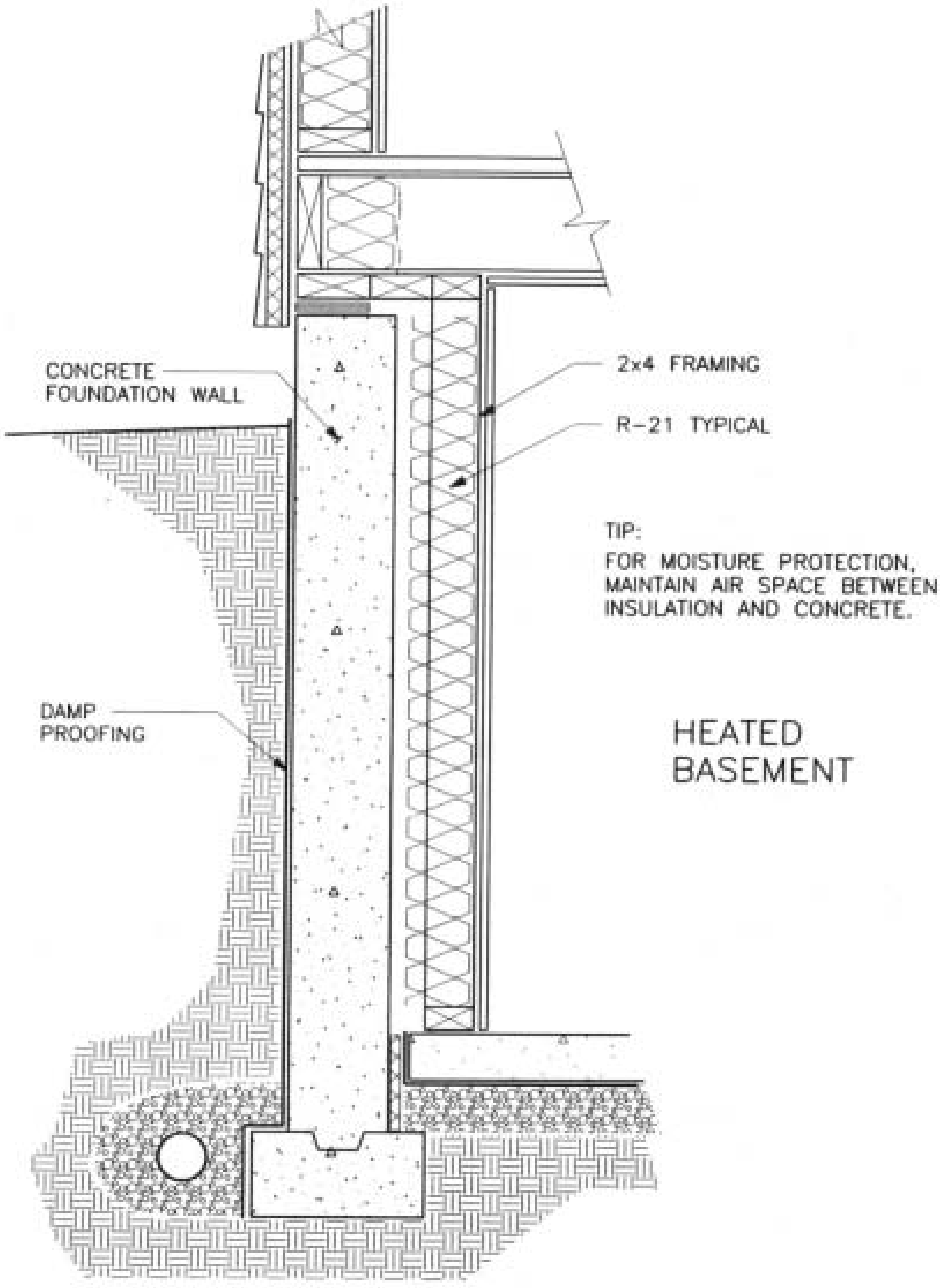

SEAL ALL PANEL JOINTS
WITH DECK ADHESIVE

Figure 4D
BELOW GRADE WALL WITH INTERIOR INSULATION



Advanced Framing Features

2x studs on 24-inch centers

Insulated headers

Insulated corners

Full insulation behind partition wall intersections with exterior walls

Intermediate Framing Features

2x studs on 16-inch centers

Insulated headers

Insulated corners

Full insulation behind partition wall intersections with exterior walls

Optional Advanced Framing Features

Studs notched on the bottom on exterior walls so wiring runs along the bottom plates and does not compress insulation

Unnecessary cripples eliminated

Header hangers that eliminate window trimmers

Figures 4F, 4G, and 4H illustrate insulated headers, insulated corners, and insulated partition intersections.

Siding/Sheathing Considerations

If you use 24-inch on center framing, make sure siding and sheathing are rated for 24-inch spans. Span ratings are stamped on sheathing materials.

Plan Advanced Wall Layout to Allow Point Loading of Trusses

While not required for all double top plate walls, it is good practice to point load the roof trusses directly above the wall studs so roof loads are transferred directly to the foundation. Lay out the two walls that bear trusses in an identical parallel pattern, and place the trusses directly above the stud layout. See Figure 41.

Installing Through-the-Wall Air Intake Vents

In many Super Good Cents homes, framers install air intake vents through the wall of each bedroom and in at least one main living area. Several ventilation options require these vents. Some vents are designed to be installed during framing. Others can be installed during finish work. Get information on vent installation from the general contractor as early as possible.

Figure 4E
ADVANCED, INTERMEDIATE, AND STANDARD FRAMING

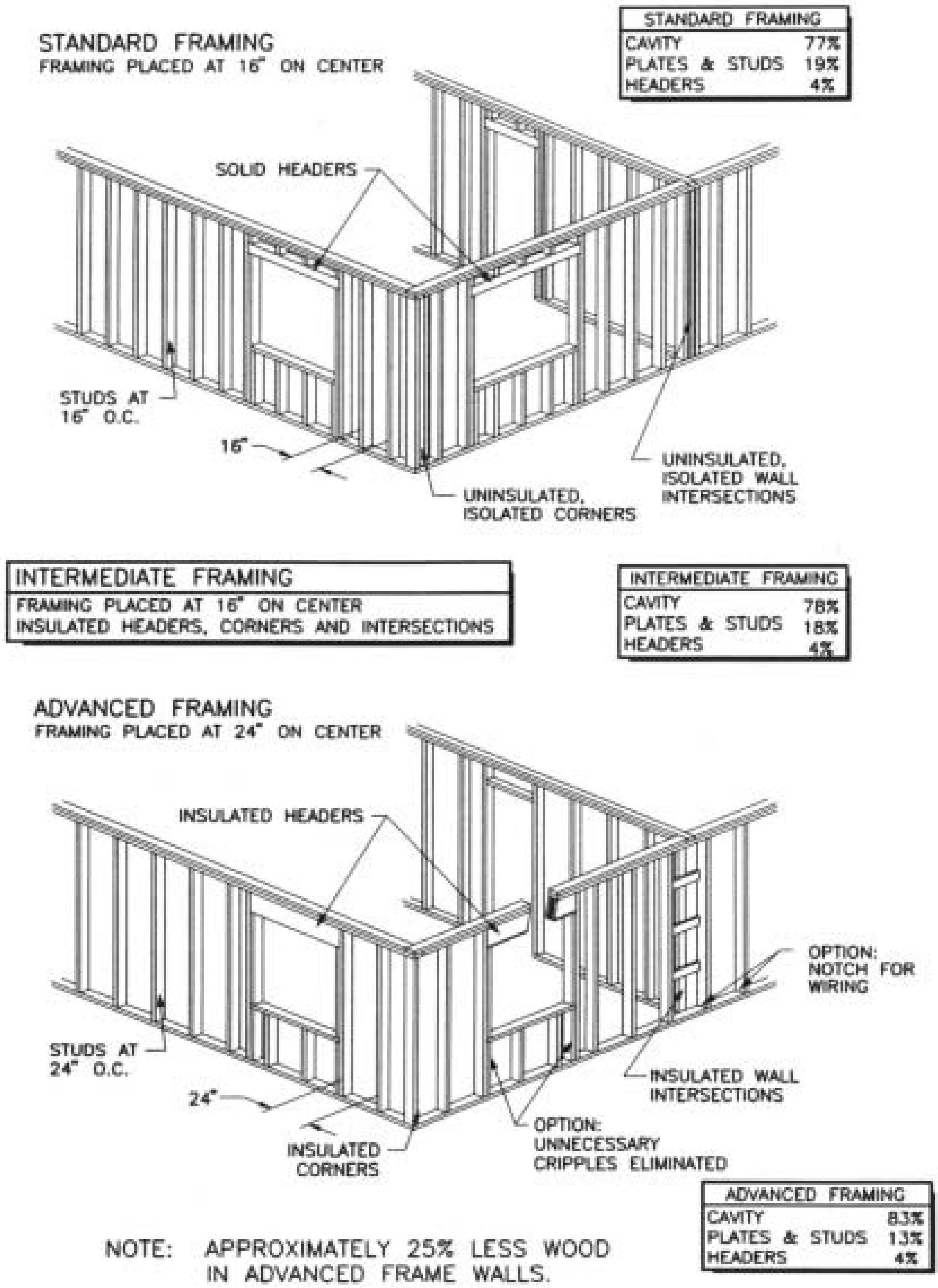
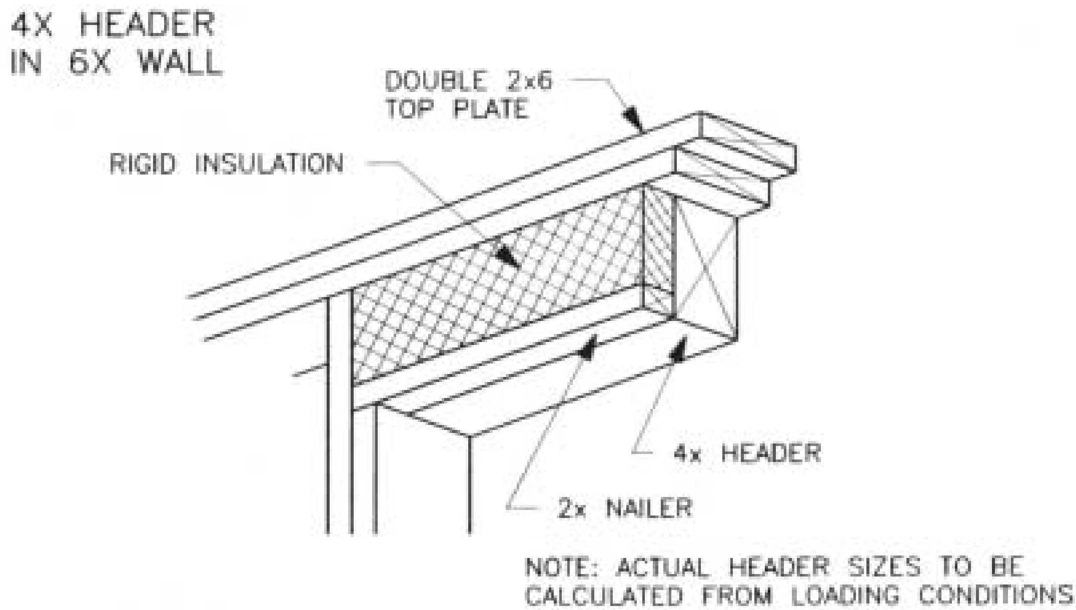


Figure 4F
INSULATED HEADER OPTIONS



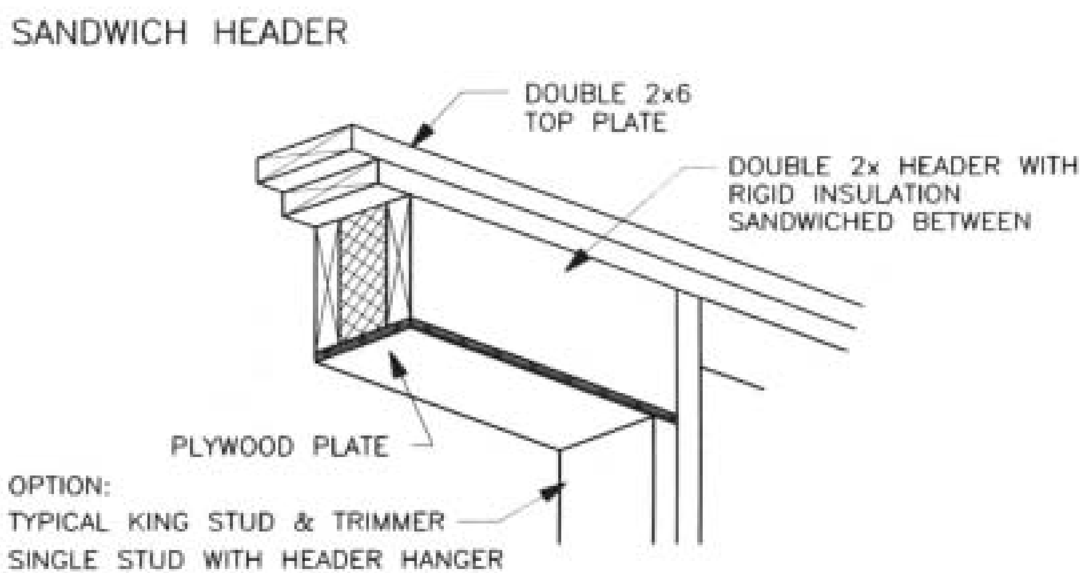


Figure 4G
INSULATED CORNER OPTIONS

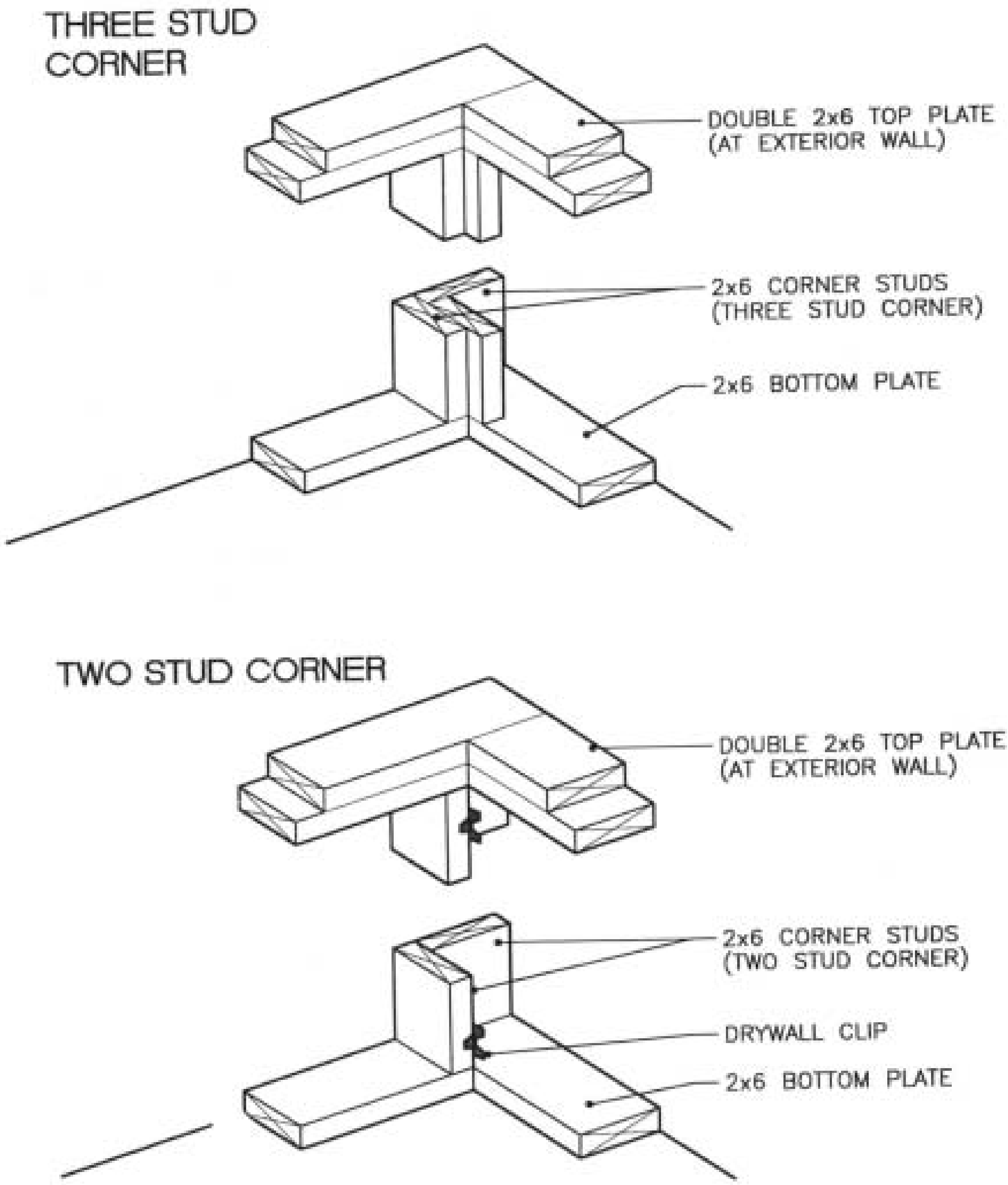


Figure 4H
INSULATED PARTITION INTERSECTION OPTIONS

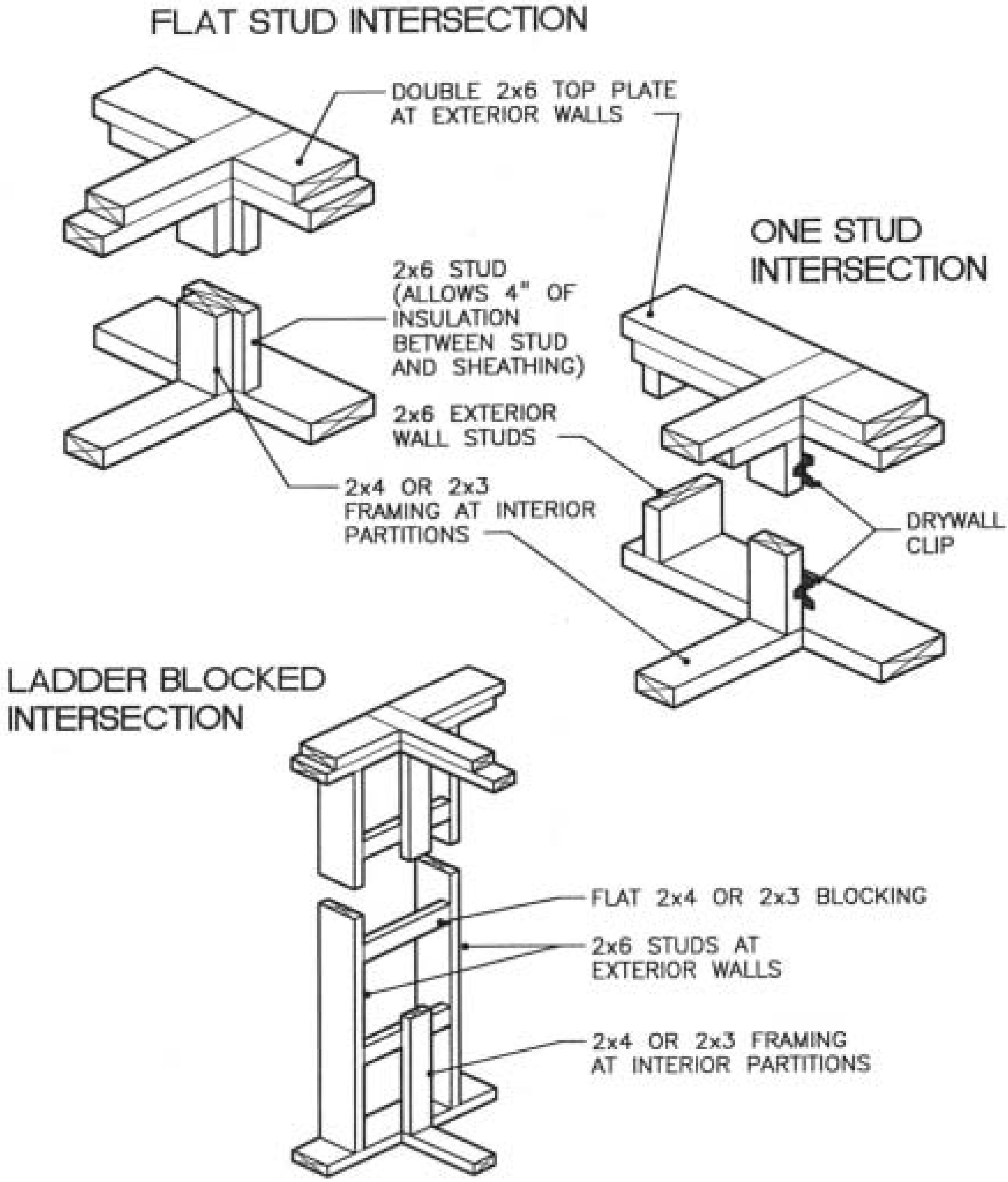
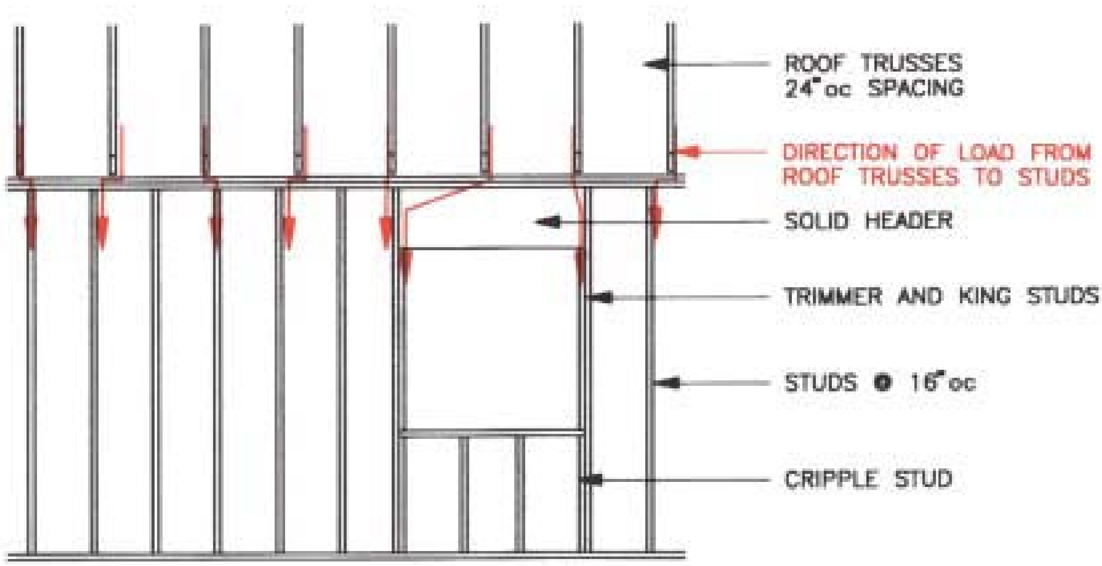


Figure 4I

POINT LOADING TRUSSES

STANDARD LOADING



POINT LOADING

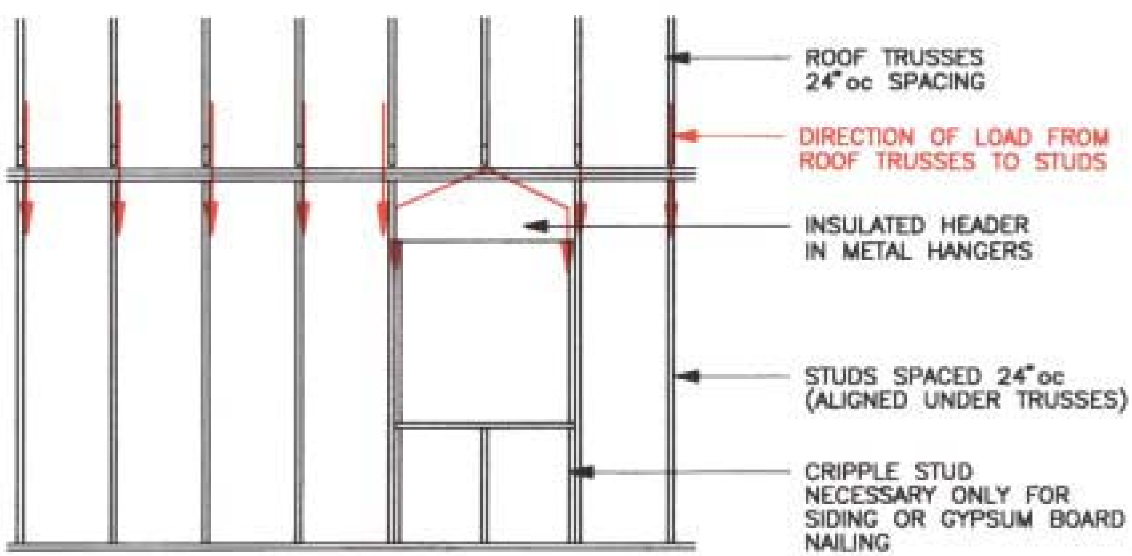
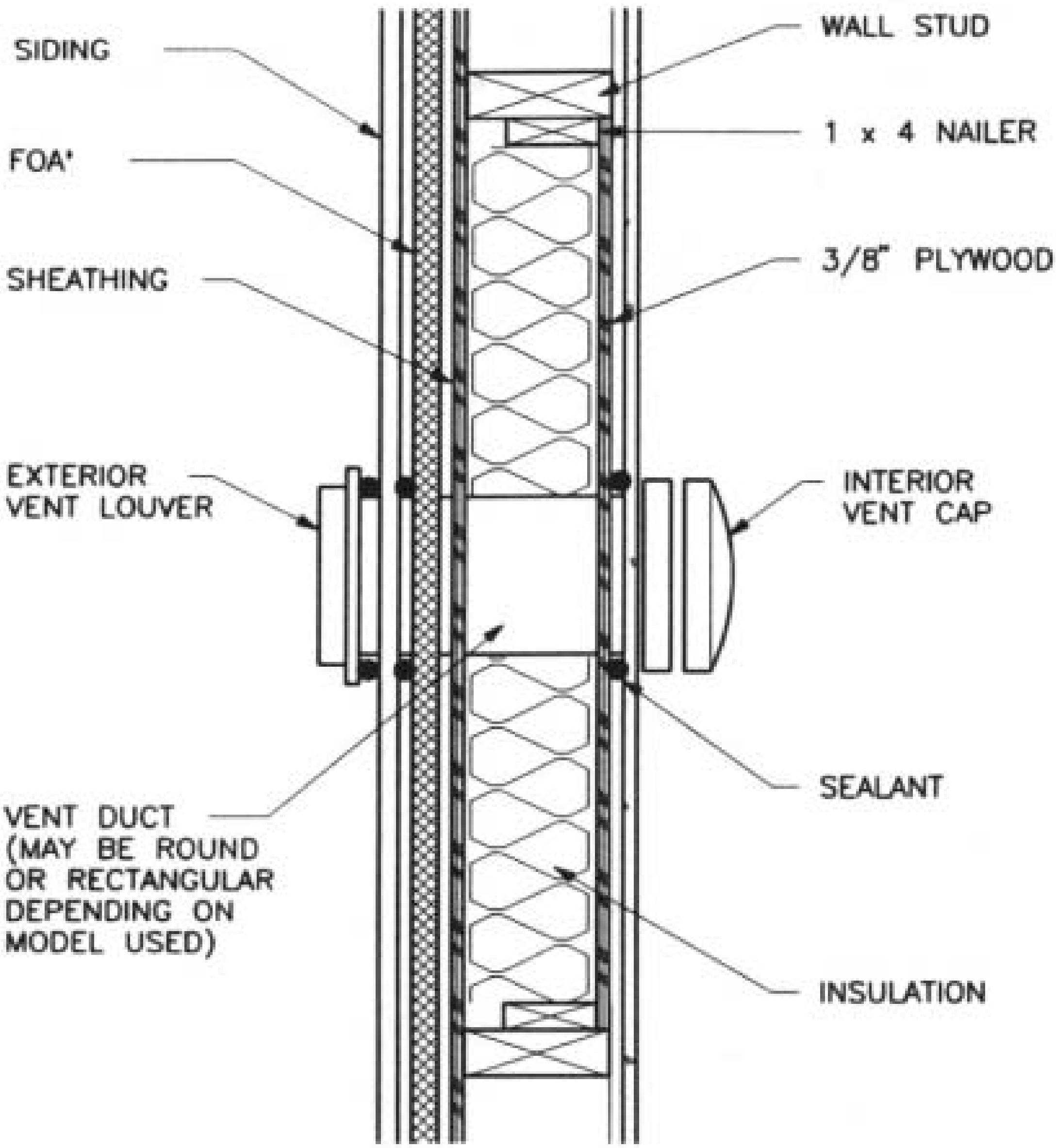


Figure 4J shows one way to install a through-the-wall vent.

TIP: Vents may need backing or other special support to take the strain of operation over a period of time. Install backing at vent locations before the drywaller closes in the walls. The framing stage is a good time to install vents so they are in place before siding and drywall.

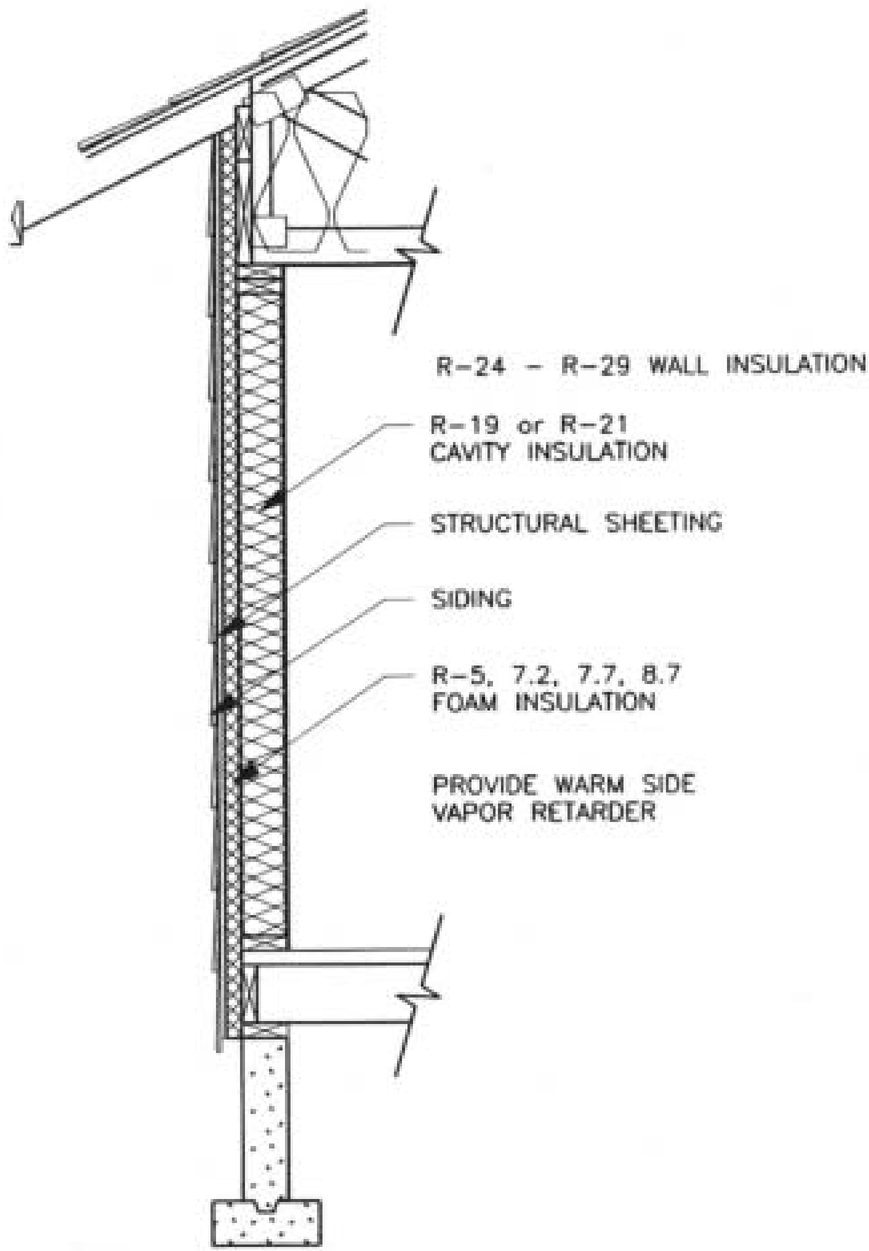
Figure 4J
AIR INTAKE VENT INSTALLATION



EXTERIOR INSULATING SHEATHING

To reduce wall heat loss, many Super Good Cents homes apply exterior insulating wall sheathing—usually rigid foam insulation. See Figure 4K. If you have not used insulating sheathing before, anticipate changes in your present practices.

Figure 4K
ABOVE GRADE WALL: EXTERIOR RIGID INSULATION



Important Advantages of Exterior Rigid Insulation

Besides substantial energy savings, exterior insulation has other advantages for wall assembly:

1. Foam sheathing is a highly effective barrier to water penetration from the exterior of the wall. This helps to minimize moisture accumulation and potential damage in exterior walls.
2. Exterior insulating sheathing helps keep the wall cavity warmer, improving drying potential of the wall. Since walls accumulate moisture during the coldest parts of the year, warming the wall during cold weather means more drying time.

Field research has found that walls with exterior foam sheathing have significantly lower moisture levels.

Structural Considerations

Foam insulation does not have structural properties. You can use your standard structural sheathing with the foam.

If you substitute insulating sheathing for structural sheathing (such as plywood or oriented strand board), and you do not use structural siding, you may need to use bracing to provide structural support for the wall. Wood or steel diagonal bracing can be used for most two-story construction.

Table 4.1 is a summary of CABO One and Two Family Dwelling Code requirements for wall bracing. The table shows just one example of code requirements for bracing. For other residential buildings, consult the Uniform Building Code or other applicable local codes.

Metal bracing may be more convenient for some builders. Some “L” and “T” metal bracing is designed to act in both tension and compression and can be installed at a 60° angle rather than at 45° to avoid interfering with window placement. Follow manufacturer’s requirements when installing metal bracing products.

In many cases, structural siding, including 303 structural sidings, may be applied over foam sheathing without additional bracing. Technical Note #C465C from the American Plywood Association (P.O. Box 11700, Tacoma, WA 98411; 206-565-6600) includes details and recommendations for this application.

Structural sheathing may be used in addition to insulating sheathing, normally with the foam on the exterior. Of course this adds thickness to walls. That affects window, door, and other trim installation. Structural sheathing also is more expensive than diagonal bracing.

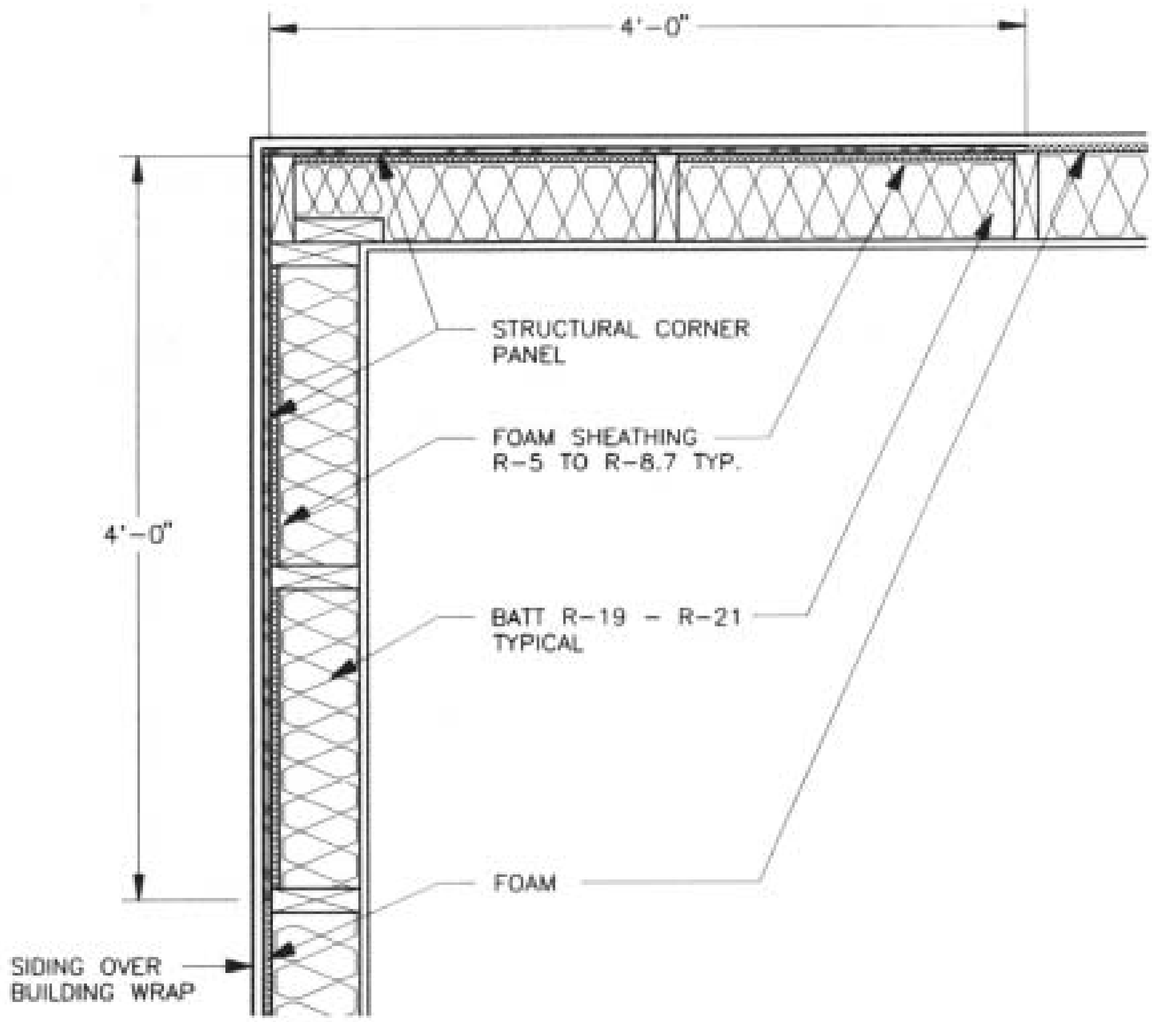
Figure 4L shows a way to inset rigid insulation to allow for more standard structural sheathing details. Wall corners built this way are slightly less efficient. The foam does not cover the framing, and insulation in the cavity is compressed somewhat by rigid foam in the cavity.

Table 4.1
TYPICAL WALL BRACING REQUIREMENTS*

	LOCATION	**BRACING**
Seismic Zones 0, l, and 2	Any story except first story of three-story	1x4 let-in bracing or structural sheathing at each end plus every 25 ft of wall length
	First story of three-story	48-inch-wide structural sheathing at each end plus every 25 ft of wall length
Seismic Zones 3 and 4	Single story or top story of two-story	1x4 let-in bracing or structural sheathing at each end plus every 25 ft of wall length
	First story of two-story or second story of three-story	Structural sheathing at least 25 percent of wall length
	First story of three-story	Structural sheathing at least 40 percent of wall length

*Summary of requirements in CABO One and Two Family Dwelling Code. Jurisdictions adopting other codes may have different requirements. Consult your local building department.

Figure 4L
CORNER WITH INSET RIGID INSULATION



Installing Siding

It is important to follow industry guidelines when installing siding over foam. Table 4.2 gives guidelines recommended by siding and insulation industry associations.

Table 4.2
NAIL SIZES FOR SIDING OVER FOAM SHEATHING

Sheathing-Siding Combinations	Recommended Nail Length	
	Smooth Shank	Ring Shank
	Penny (inch)	
Bevel Wood or Hardboard:		
1/2" Siding + 1/2" Foam Sheathing	9d (2-3/4”)	7d (2-1/4")
1/2" Siding + 3/4" Foam Sheathing	l0d (3")	8d (2-1/2")
1 /2" Siding + 1" Foam Sheathing	12d (3-1/4")*	10d (3")
5/8" or 3/4" Siding + 1/2" Foam Sheathing	l0d (3")	8d (2-1/2")
5/8" or 3/4" Siding + 5/8" or 3/4" Foam Sheathing	12d (3-1/4")*	9d (2-3/4")
5/8" or 3/4" Siding + 1" Foam Sheathing	16d (3-1/2")*	l0d (3")
APA Rated Structural Siding:		
1 /2" or less Siding + up to 1" Foam Sheathing	8d box	—
Greater than 1/2" Siding + up to 1" Foam Sheathing	l0d box	—

*These diameters may cause wood siding to split. Pre-drill siding to prevent splitting.

Information from:
Guidelines for Installing and Finishing Wood Siding Over Rigid Foam Sheathing, Western Wood Products Association, Yeon Building, 522 SW Fifth Ave., Portland, OR 97204-2122; 503-224-3930.

Plywood Siding Over Rigid Foam Insulation Sheathings, Technical Note HC465, American Plywood Association, P.O. Box 11700, Tacoma, WA 98411; 206-565-6600.

Performance of lap siding is likely to be improved by providing a 3/8-inch or larger air space between siding and sheathing, regardless of the sheathing material. In fact, some siding manufacturers require an air space when their materials are applied to foam sheathed walls. This air space allows siding to dry from both front and back, reducing any splitting or cupping.

The usual method of providing an air space is to nail furring strips into each stud to hold the siding away from the sheathing. Install bug screens at openings at the top and bottom of siding.

Many stucco-like finishes are designed for application over foam insulation. Each manufacturer recommends a specific application procedure.

Trimming Corners and Openings

Rigid insulation adds thickness to walls and is nonstructural. These two factors require you to pay special attention to providing backing at comers and rough openings for trim. Figures 4M and 4N show typical details, but feel free to design your own. Many options are possible.

Just be sure you frame so that there is nail backing for all trim pieces. Figure 4N shows a 2x4 turned flat for corner board backer. Turning the backer flat allows cavity insulation to get all the way into the corner.

OTHER ENERGY EFFICIENT WALL SYSTEMS

Double Wall Construction

Typical double wall construction consists of two 2x4 walls with 3-1/2 inches or more between them. The inside wall is usually nonstructural. This allows for inexpensive R-11 batts in stud cavities and between walls for a total insulation value of R-33 or higher.

Framing techniques for these walls are not unusual. Work out the following details with the general contractor to help you make your bid:

1. How will window and door rough openings be framed? A plywood wrap is typical.
2. How should you fire stop the walls at the top plates? A 2x the same width as the space between the walls is typical. Some builders cap the top with plywood as the fire stop.

Figure 4O shows double-wall construction details.

Figure 4M
DOOR REINFORCEMENT FOR EXTERIOR RIGID INSULATION

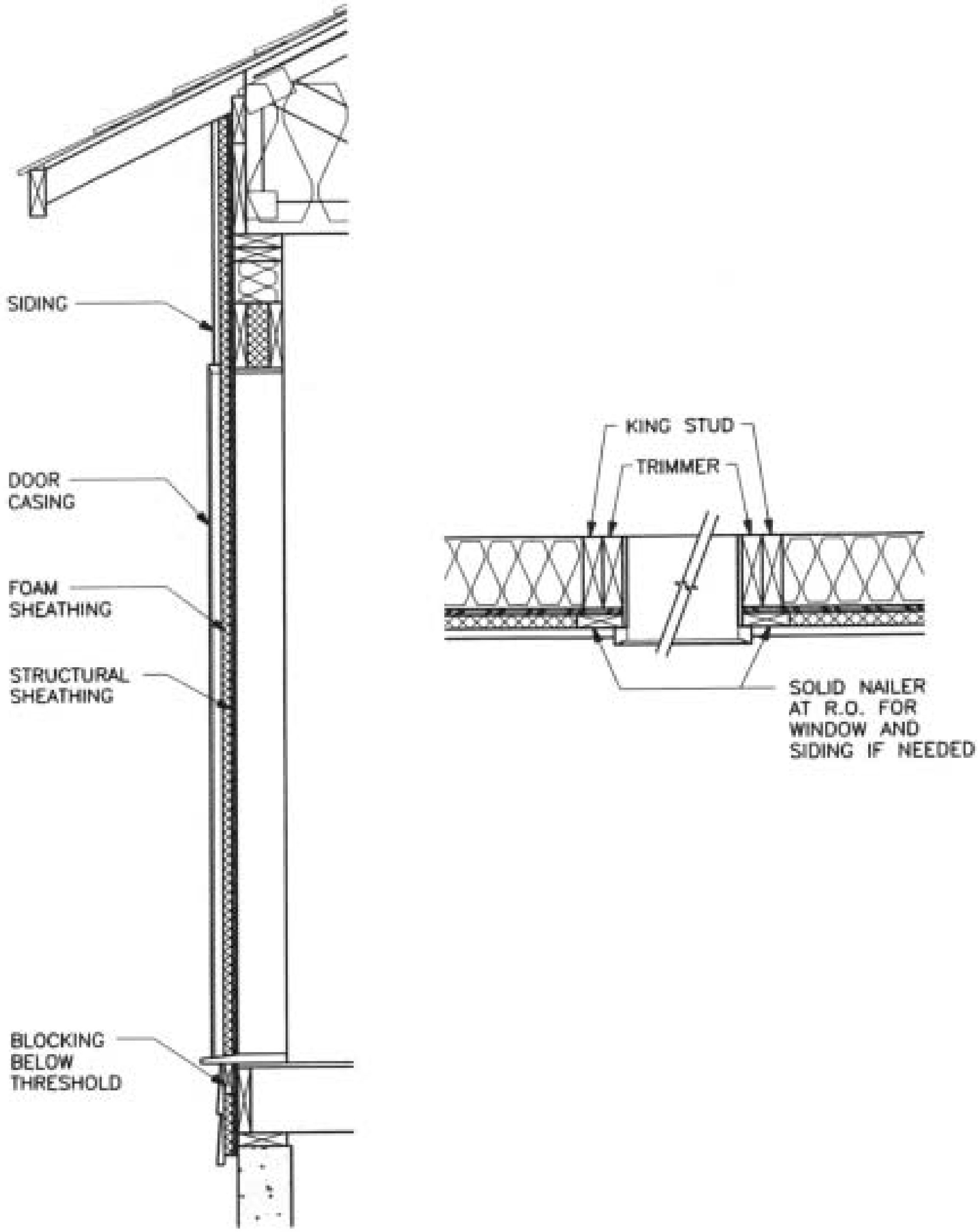


Figure 4N
CORNER TRIM DETAIL FOR EXTERIOR RIGID INSULATION

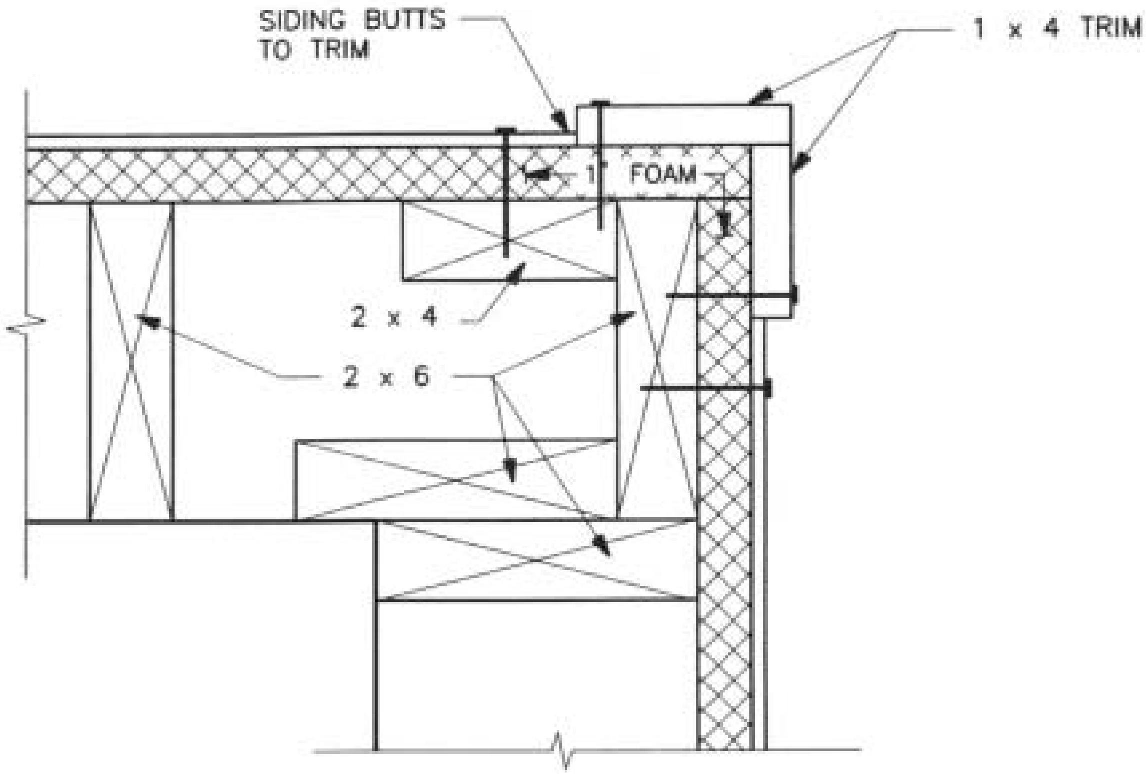
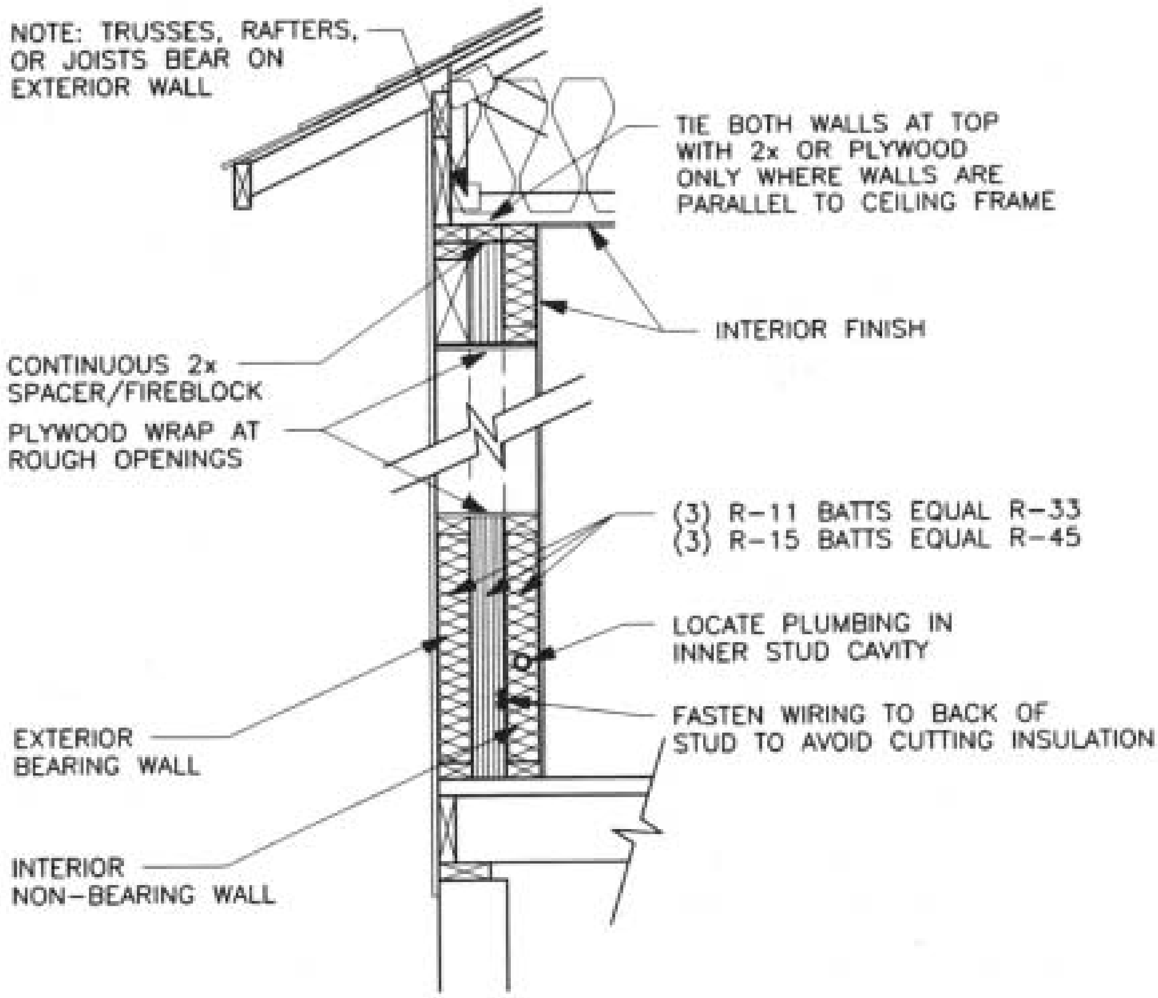


Figure 4O
DOUBLE WALL



Stress Skin Walls

Stress skin panels consist of a foam core with structural sheathing glued to both sides. Panels range in size from 4x8 ft to 8x28 ft. They typically are rated for use up to three stories with no additional framing material other than top and bottom plates, window and door openings, and headers for long spans. Some panels, including a 6-1/2-inch panel that uses 1-1/4 lb per ft^3 EPS (expanded polystyrene) foam, have energy performance equal to R-26 advanced frame walls. Stress skin panels that use polyurethane foam do not have to be as thick as panels that use EPS to achieve the same R-value.

Many manufacturers produce stress skin panels. Their methods for site assembly differ. If you are working on a house with stress skin panels, have the manufacturer's instructions available onsite. The building department may not be familiar with stress skin panels. Call attention to the panels when you go in for plan review so inspectors will not be surprised onsite. See Figure P.

Advantages of stress skin walls include:

- Siding and interior finish materials are easily applied when skins are nail base rated.
- Moisture is unlikely to enter the wall from inside or outside.
- The building can be closed in quickly if you use large panels.

There are disadvantages too:

- Higher material cost (may be offset by labor savings).
- May need to frame spaces to run plumbing.

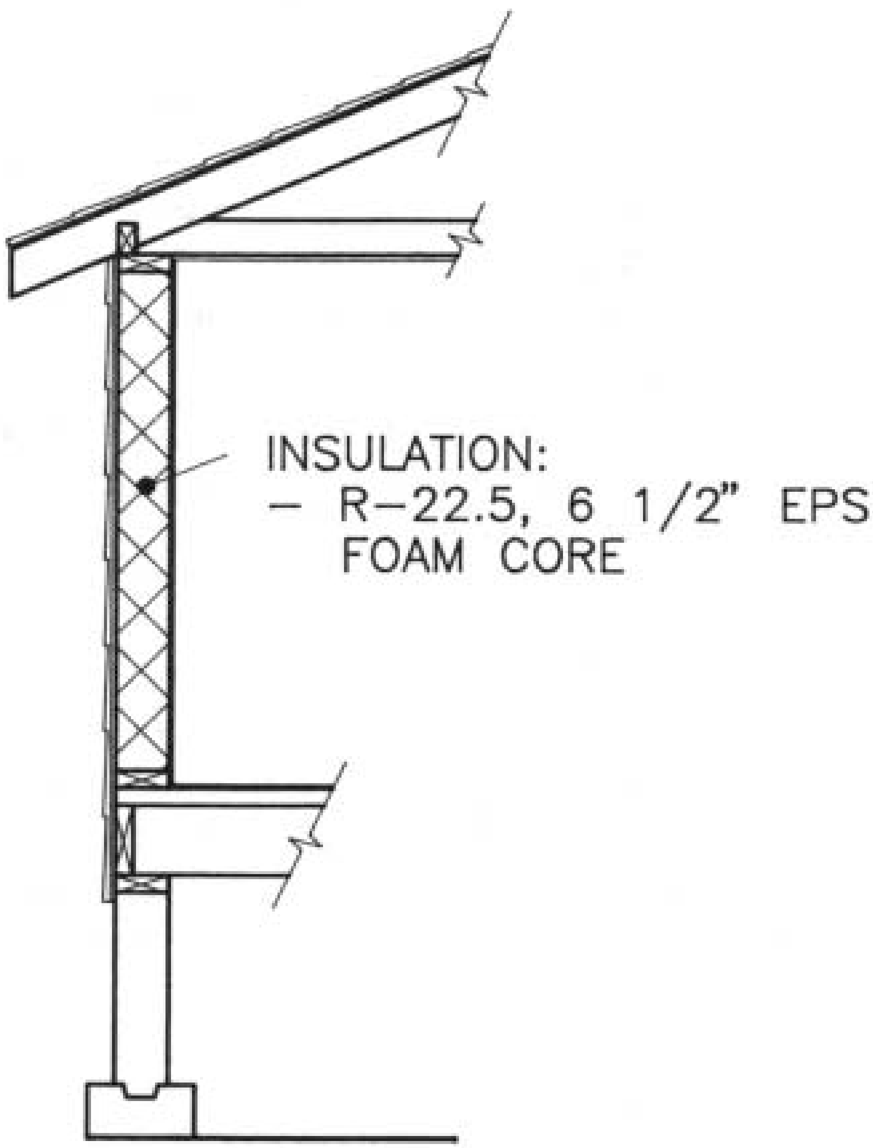
Interior Rigid Insulation

Installing rigid insulation on the inside of the wall provides the same overall R-value as exterior installation. Interior rigid insulation may be installed by crews other than the framers since it goes on after the wall cavity is insulated. Ask the general contractor who will be doing this work.

Three advantages of interior application are:

1. Structural requirements are easily met because it requires no changes to sheathing or siding applications.
2. Rigid foam can double as a vapor retarder if it has a perm rating of less than 1 (foil-faced foam board or extruded polystyrene).
3. If the foam is taped or caulked so that it forms a continuous air barrier, and if it is sealed to ceiling and floor continuous air barriers, it can be part of a whole house continuous air barrier (used in Advanced Air Leakage Control).

Figure 4P
STRESS SKIN PANEL WALL



Disadvantages of interior insulation application include:

1. Nailers and extra drywall backing must be installed around windows, doors, corners, and wall intersections for attaching trim and drywall.
2. Locations of studs must be marked on the inside of foam insulation so drywall installers can find them.
3. Electrical boxes and plumbing stubs must allow for added thickness of the insulation.
4. The wall cavity stays cooler, reducing its drying potential compared to exterior insulation.
5. Interior insulation is not a barrier to exterior sources of moisture as is insulation installed on the outside.

Figures 4Q and 4R show interior rigid foam details.

Strap Walls

Nailing 2x strapping on the inside of 2x6 exterior walls is another option for adding insulation. Typically, high density batts (usually sold for commercial buildings) are installed in the strapping space. See Figure 4S. Often, wiring and plumbing are located in the strapped spaces to avoid interfering with insulation in the main wall cavity.

In most strap walls, the vapor barrier is installed between the main wall framing and the strapping. Ask the general contractor before you finalize your bid if you are expected to do this.

Advantages of strap walls include:

- Ease of running plumbing and wiring without compressing insulation in the main wall cavity.
- Allow for standard sheathing and siding application and nearly standard drywall installation.

Disadvantages of strap walls include:

- Added depth in walls requires casing/jamb extensions for doors and windows.
- Require fire stops between strapping at 10-ft intervals.
- Require additional drywall backers in corners.
- Affect wiring boxes and plumbing stubs.

Figure 4Q
ABOVE GRADE WALL: INTERIOR RIGID INSULATION

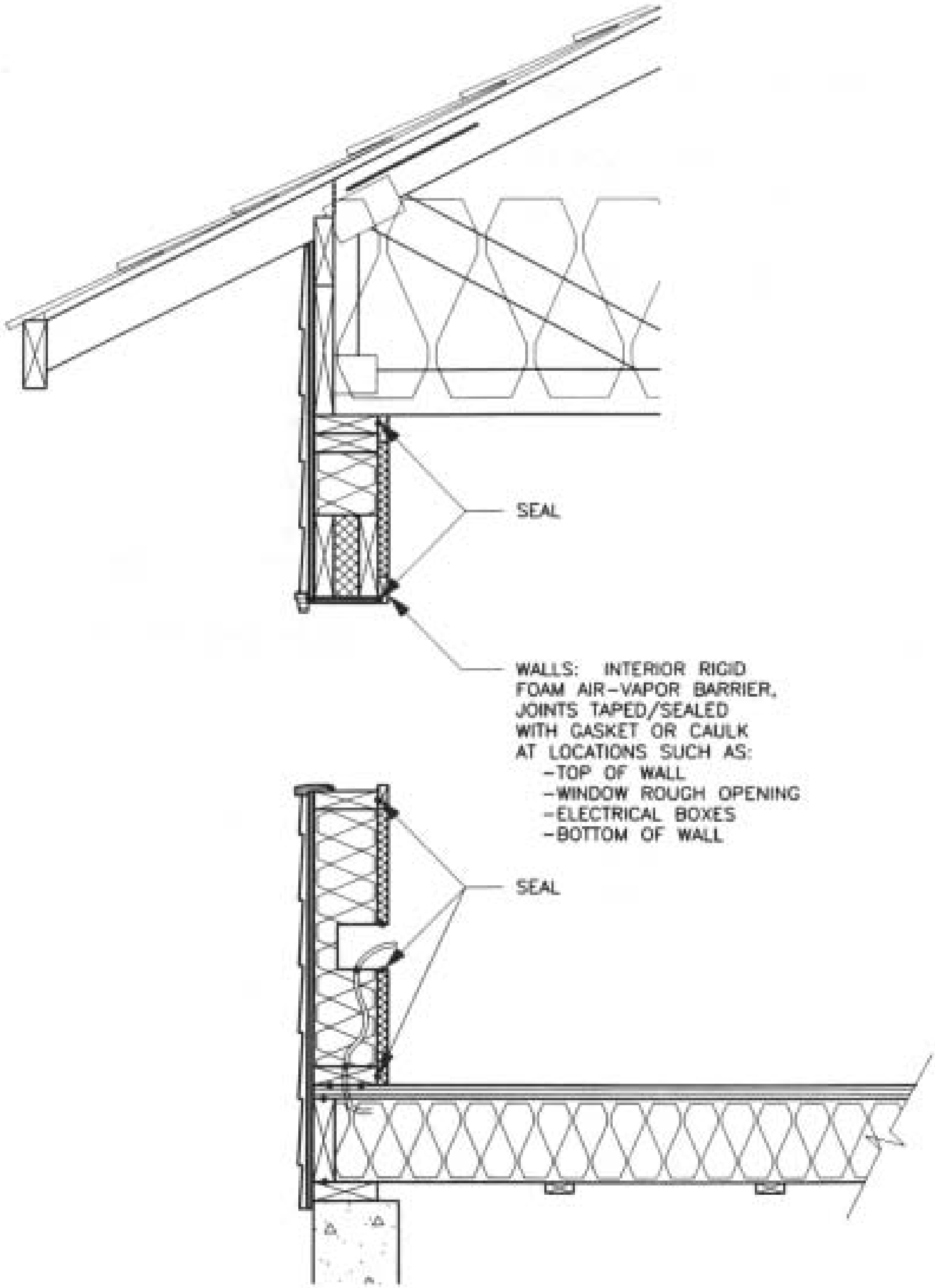


Figure 4R
INTERIOR RIGID FOAM FRAMING DETAILS

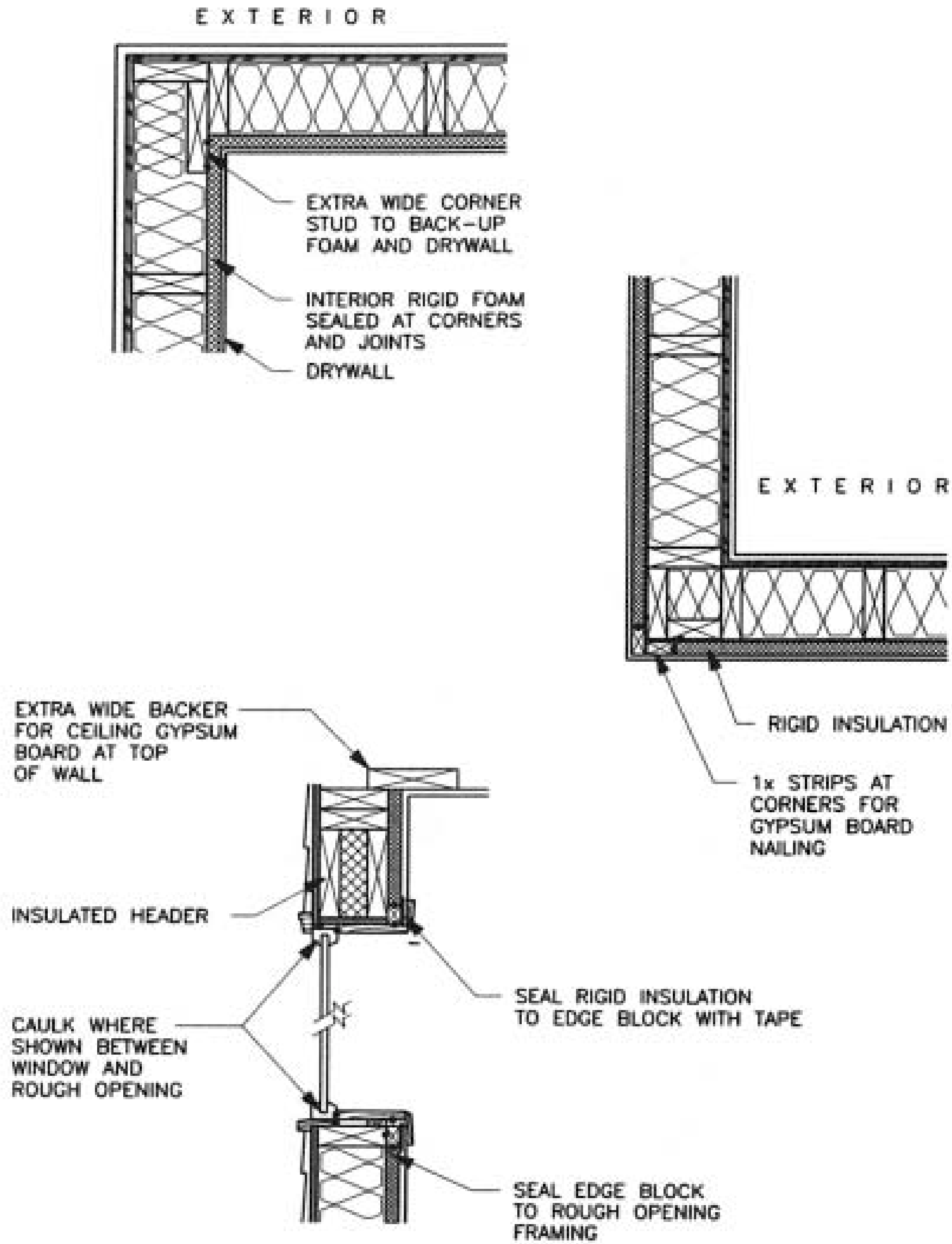
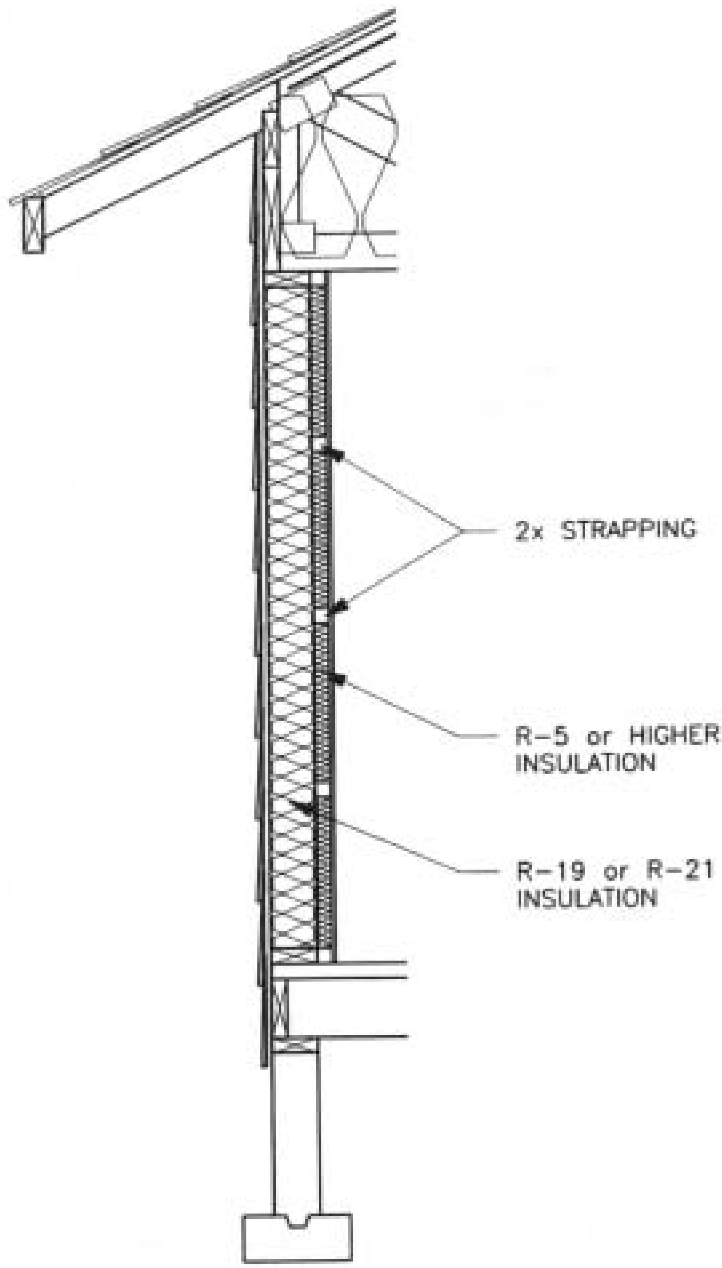


Figure 4S
STRAP WALL



ENERGY EFFICIENT CEILING AND ROOF FRAMING

Advanced Ceiling and Roof Framing

The way you frame a ceiling and roof affects the energy performance of a home. Many Super Good Cents homes use advanced roof framing techniques to minimize ceiling heat loss.

The main objective of advanced ceiling framing is to provide enough space at the ceiling perimeter so that the entire ceiling area can be insulated to the full R-value. In standard ceiling framing, the slope of the top chord or rafter reduces height available for insulation at the ceiling perimeter. See Figure 4T.

Advanced framing allows for full insulation values by using raised heel trusses, oversized trusses, high R-value per inch insulation, or combinations of framing and high R-value insulation. The specification allows any combination of insulation materials, heel height and baffles that provides at least R-25 at the outside of the exterior wall, increasing to R-38 at the inside of the exterior wall, and leaves a ventilation space between the insulation and the roof sheathing.

Advanced Trusses

A raised heel truss is an exposed rafter tail truss with webbing members that raise the height of the top chord. Raised heel trusses allow extra space for insulation over the exterior walls. If the plan calls for raised heel trusses, check with the general contractor about how the extra height to rafter tails will be finished. Your bid needs to include extra materials for this additional area.

An oversized truss (sometimes called a cantilever truss) is longer than a standard truss. The extra length provides added height above the exterior wall. Soffits typically are closed in, so include this extra cost in the bid.

The point on the truss that bears on the exterior wall is different for an oversized truss and a standard truss. Specify to the truss manufacturer where this point is. If trusses that arrive onsite do not have a web member that lines up over exterior walls, check with the truss supplier to make sure you have the right trusses.

As with any roof truss, raised heel and oversized trusses must be blocked or braced to provide shear resistance and to prevent “rolling.” Consult the truss manufacturer for specific recommendations. To avoid the cost of solid 2x blocking, your truss manufacturer may be able to make up blocking made of a 2x frame with plywood or oriented strand board webbing.

Figure 4T
STANDARD AND ADVANCED ROOF FRAMING

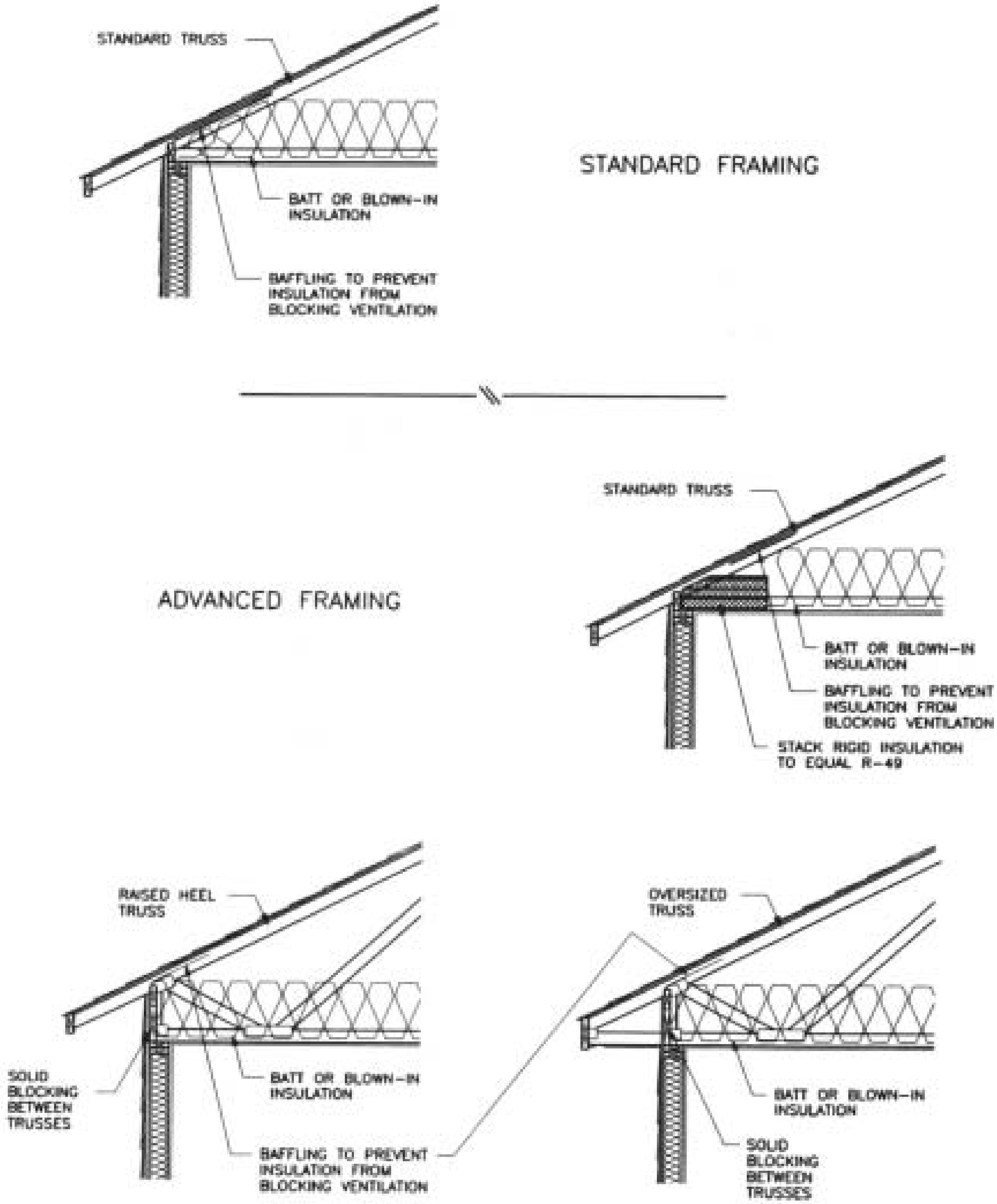
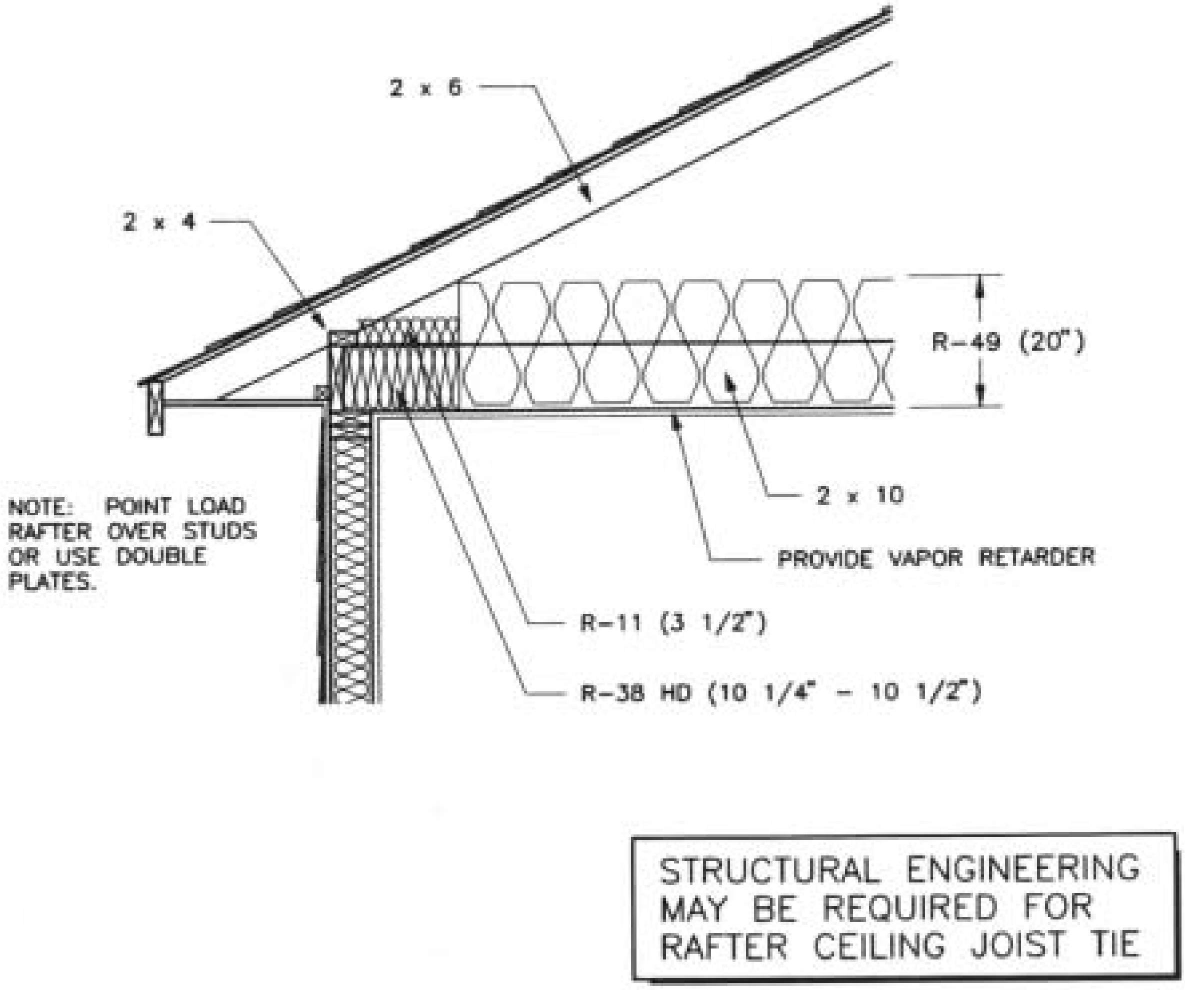


Figure 4U
ADVANCED RAFTER FRAME ROOF



Advanced Stick Frame Roofs and Ceilings

You can get extra height for insulation for stick frame roofs by adding a "plate" to the top of ceiling joists and resting the rafter on that plate instead of the ceiling rim joist. See Figure 4U. Height available for insulation is determined by size of ceiling joists and rafters.

IMPORTANT: Stick frame roofs are not standard. They must be engineered on a case-by-case basis. Rafters must be tied to ceiling joists with straps or ties to resist horizontal roof loads. Consult with a structural engineer for appropriate structural ties and fasteners. You may need to block rafters to prevent rolling.

How Much Height Do You Need?

To meet Super Good Cents requirements for advanced roof framing, the insulation value over the top plates of outside walls must be at least R-38 at the inside wall edge. Table 4.3 shows the height needed to achieve R-38. Most utilities accept as advanced framing trusses that have 12 inches of height available for insulation above outside walls.

Table 4.3
TYPICAL INSULATION THICKNESSES FOR R-49 AND R-38
(not including ventilation space, typically 1")

	R-49	R-38
Fiberglass:		
Blown-in	20"	16"
Standard batts	16"	12"
High density batts	14.5"	10"
Other Mineral Wool (rock wool)	14.5"	11"
Cellulose (blown-in) (R-3.5 per inch)	14"	11"
Foam:		
Urethane/isocyanurate (R-6.2 to R-7.2 per inch)	7-8"	5-6"

To minimize height required for advanced framing, you can use insulation with a higher R-value per inch over exterior walls. Urethane foam, for example, can provide R-38 with 6 inches of clearance. This allows for advanced framing with standard trusses that use 6x top chords.

With a raised heel truss, getting adequate height for insulation is fairly simple. Just specify the height of the heel that gives at least 12 inches of height for insulation. For example, with 2x4 trusses, the raised heel must raise the top chord roughly 6 inches above the bottom chord. Width of the top and bottom chords gives you the rest of the height you need for insulation.

Things get a little more complicated with oversized trusses. Length of the overhang and pitch of the roof determine height available for insulation.

Table 4.4 shows the height available for insulation for oversized trusses. Measurements include space provided by the top and bottom chords and allow for a 1-inch space above insulation for ventilation.

The table shows that even with a 24-inch overhang, a 4/12 pitch does not allow for 12 inches of blown insulation. However, a 24-inch overhang provides room for an R-38 high density batt.

Table 4.4
HEIGHT AVAILABLE FOR INSULATION IN OVERSIZED TRUSSES
(from bottom of bottom chord to 1" below top of top chord)

	OVERHANG		
ROOF PITCH	**12"**	**18"**	**24"**
4/12	6.5"	8.5"	10.5"
6/12	9"	12"	15"
8/12	11"	15"	19"
10/12	13.5"	18.5"	23.5"
12/12	16"	22"	28"

Attic Ventilation for Flat Ceilings

1994 LTSGC 4.2.1

Attic venting helps prevent moisture buildup in attics to keep insulation dry and prevent structural damage. In summer, venting reduces heat buildup in attics that can cause living spaces to overheat and air conditioning bills to soar. Roofing materials may last longer when installed over vented areas.

When vents are placed both near the ridge and at the eaves, the Super Good Cents program requires 1 ft^2 net free area of vent for every 300 ft^2 of ceiling area. Figure 4V is an example of how to calculate needed vent area and number of vents.

When all vents are at the same level (only gable end vents, for example), 1 ft^2 net free area of vent is required per 150 ft^2 of ceiling area.

Vent Placement

Attic ventilation is most effective when half the vent area is near the eave and half is near the ridge. This vent scheme takes advantage of the "stack effect": Warm air rises and exits through higher vents, drawing in cooler air from lower vents.

One-level venting may meet requirements, but it is not as effective at moving air through the attic. In summer, homes with one-level venting may have greater heat buildup above the ceiling.

Eave Baffles

The eave vents will not work if they are blocked by insulation. Framers often install baffles after the roof is sheathed and before the framing inspection. Baffles keep insulation from blocking lower vents. In some cases, the insulator installs baffles before the wall insulation inspection.

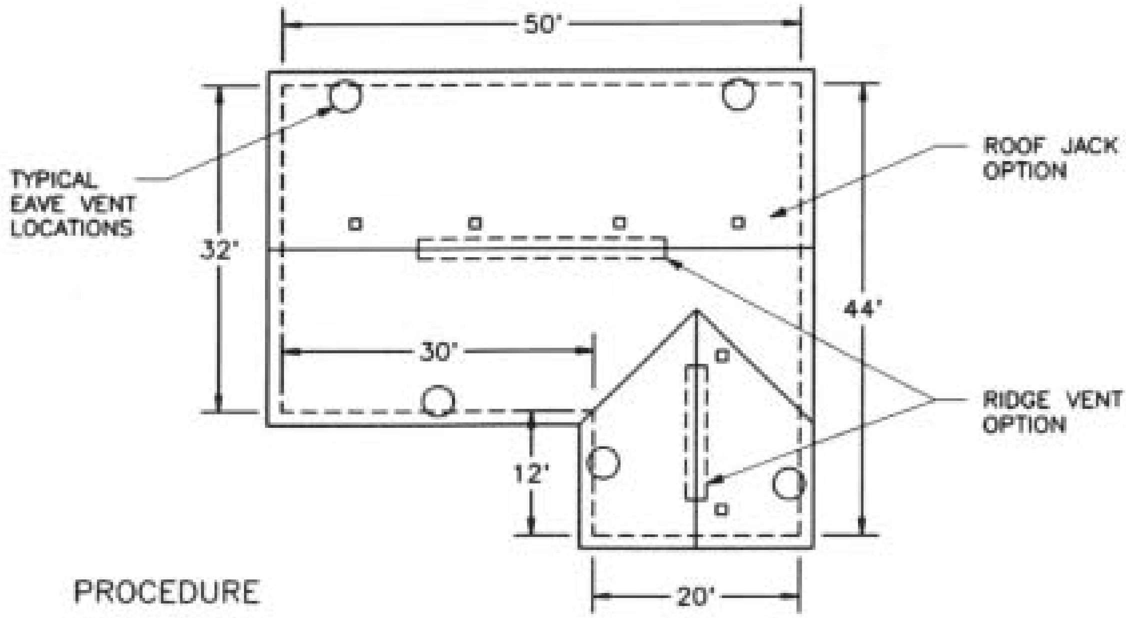
Figure 4W shows baffles for two types of advanced frame trusses. Install baffles to allow a 1-inch air path between the baffle and roof sheathing. That provides maximum room for insulation. Install baffles at the outside of wall top plates so insulation can be installed over outside walls.

Ridge Vents

If standard vent jacks provide venting near the ridge, the framer typically is responsible for cutting the hole in the roof sheathing and pinning the jack near the hole. The roofer installs the jacks later.

If instead the home has continuous ridge vents, the framer is responsible for cutting the sheathing back from the ridge peak 1 or 2 inches on each side of the peak.

Figure 4V
ROOF VENTILATION



PROCEDURE

1. CEILING AREA
   EXAMPLE: (32 x 50) + (12 x 20) = 1840 sf

2. VENT AREA REQUIRED
   EXAMPLE: 1sf VENT PER 300sf CEILING AREA
   $$\frac{\text{1840sf CEILING AREA}}{300} = \text{6sf TOTAL VENT AREA REQUIRED}$$

3. DISTRIBUTE VENTS
   EXAMPLE: 50% (3sf) AT RIDGE
   50% (3sf) AT EAVE

4. NUMBER OF VENTS:

   EAVE VENTS: $$\frac{\text{3sf REQUIRED AREA}}{\text{0.9sf NET FREE AREA PER VENT}} = \text{3–4 VENTS}$$

   RIDGE VENTS: $$\frac{\text{3sf REQUIRED AREA}}{\text{0.6sf NET FREE AREA PER VENT}} = \text{5 VENTS}$$

   – OR –

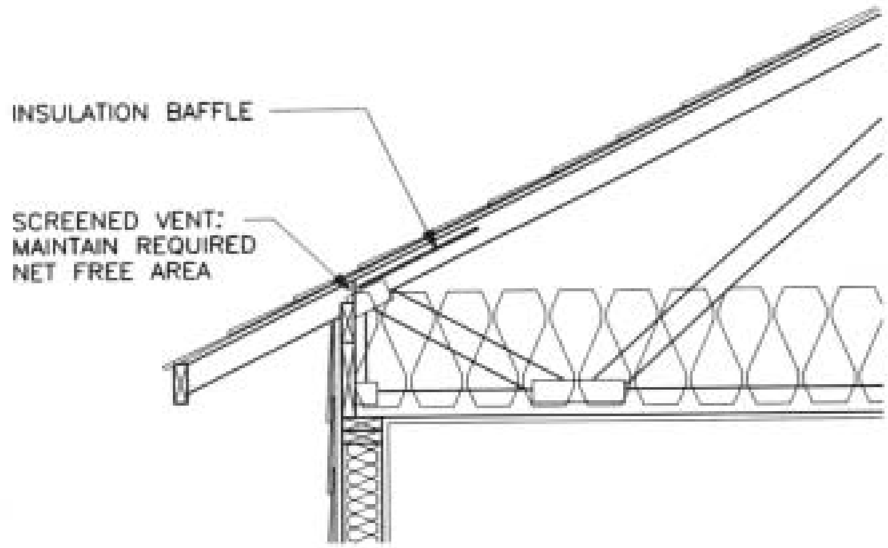
   CONTINUOUS RIDGE VENT:

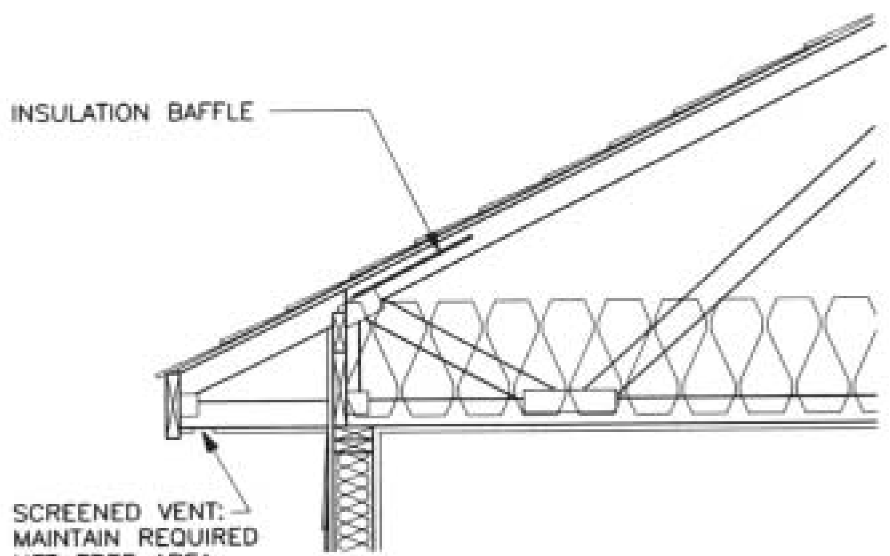
   $$\frac{\text{18 sq.in. PER lin. ft.}}{\text{144 sq.in. PER sq.ft.}} = \text{0.125 sq.ft. PER lin. ft.}$$

   $$\frac{\text{3sf REQUIRED AREA}}{\text{0.125sf}} = \text{24 LIN. FT.}$$

NOTE: VENT RATIO MUST BE INCREASED TO 1/150 IF VENTS ARE ALL ON ONE LEVEL.

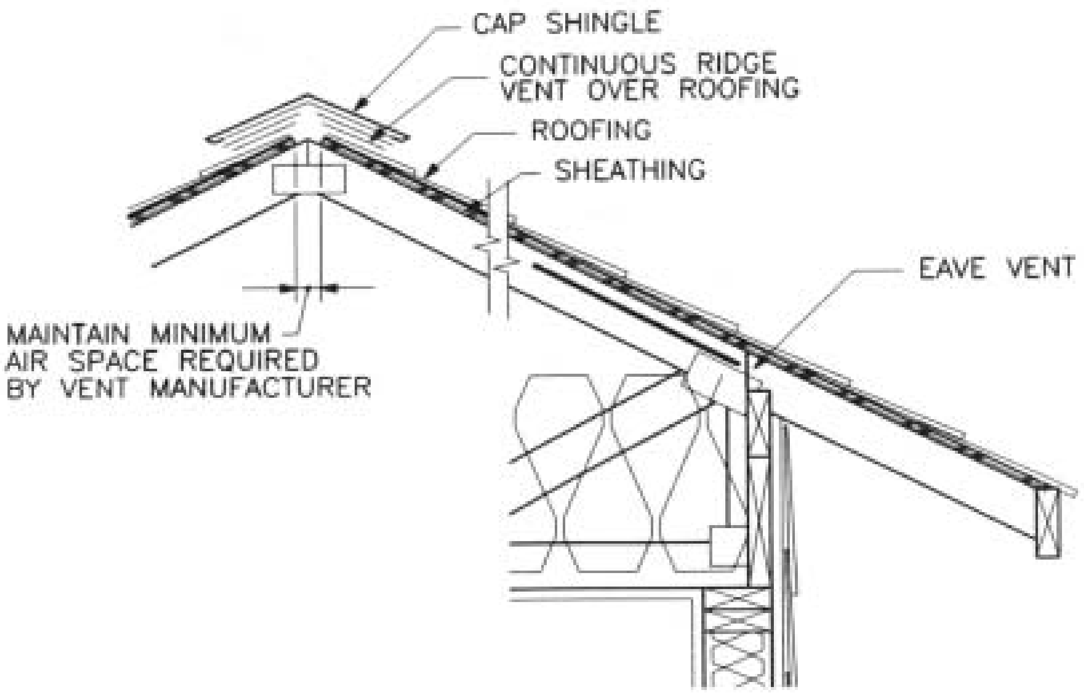
Figure 4W
METHODS FOR BAFFLING AT EAVES





NOTE:
STATE CODE MAY SPECIFY HOW FAR THE BAFFLE MUST EXTEND BEYOND THE INSULATION.

Figure 4X
CONTINUOUS RIDGE VENT OVER ATTIC



Consult the ridge vent product literature for exact dimensions of the cut. Figure 4X shows a typical detail.

Fan Vents

To keep fan duct runs short, dedicated fan vents may exit through the roof directly above each fan.

Framers may be responsible for cutting holes for fan vents. Pin vents in place for the roofer to install later.

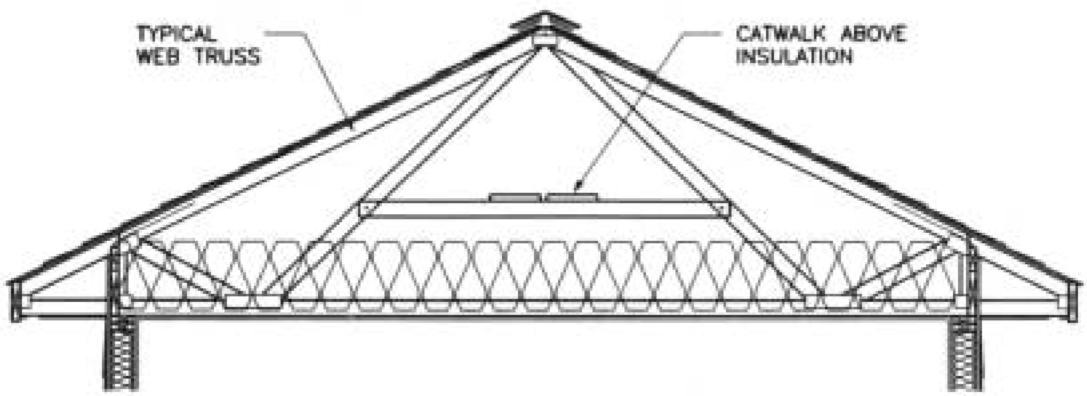
Attic Access

Framers also install the attic access hatch. A leaky attic hatch inside the heated space allows significant heat loss to the attic. It also allows moist air from the house to get into the attic, where it can cause moisture problems. The best place for an attic entry is outside the heated space—in the garage ceiling, for example.

Catwalk

The finished attic often contains more than 20 inches of insulation. If there is room, frame in a catwalk above the insulation. A catwalk allows access to all parts of the attic without disturbing insulation. See Figure 4Y.

Figure 4Y
ATTIC CATWALK



Vaulted Ceilings

Vault cavities restrict space for insulation. It can be challenging to achieve Super Good Cents levels of insulation in vaults. Figure 4Z-1 shows a standard stick frame vault and other framing options for achieving high vault R-values.

With newer insulation materials such as high density batts and high R-value per inch blown-in materials, Super Good Cents insulation levels can be achieved with 12x rafters. Many contractors use wood I-beams or other types of parallel trusses in vaulted ceilings. These materials make it easier to get deep vaults with lower weight, easier handling and less seasonal wood movement.

One new method using wood I-joists is to cut and fit rigid foam insulation between the joists, using the joist flanges to hold insulation in place.

Another way to get high vault R-values is to use stress skin panels engineered for use as vaulted ceiling panels. They are similar to the stress skin wall panels discussed earlier in this chapter. Panels are available that exceed Super Good Cents requirements for vaults.

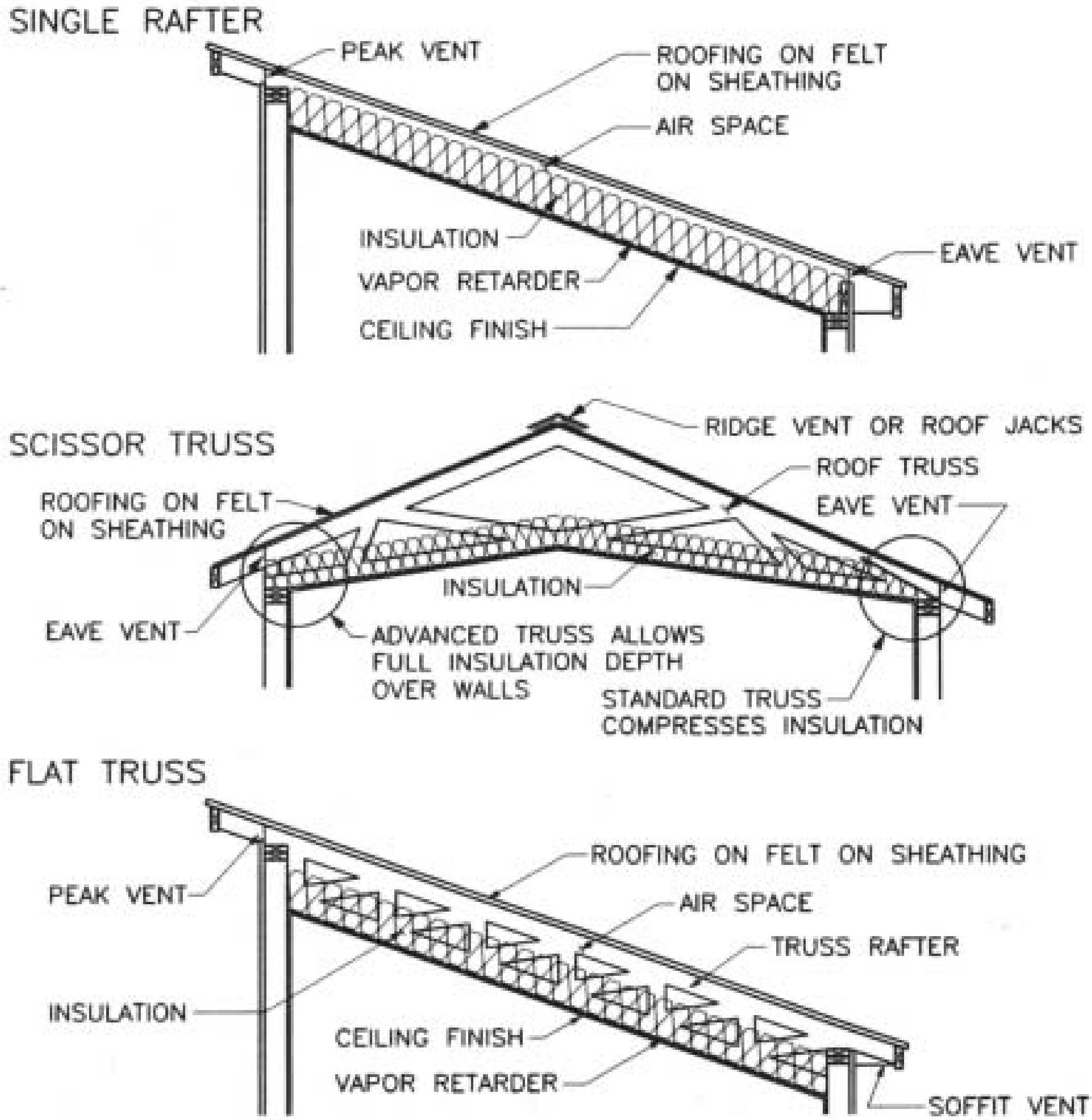
Stick with the vault depth and R-values shown on approved plans. If you need to make a change, let the Super Good Cents utility representative know.

Vault Cavity Ventilation

1994 LTSGC 4.2.1

Super Good Cents specifications call for ventilation above all ceiling insulation, including vaulted ceilings.

Figure 4Z-1
VAULT FRAMING METHODS:
SINGLE RAFTER, SCISSOR TRUSS, AND FLAT TRUSS



One level venting should equal 1 ft^2 net free vent per 150 ft^2 ceiling area. The ventilation ratio for high-low venting is 1/300. Vault ventilation is easier with scissor trusses, deep flat trusses, and wood 1-beams than with stick-frame single rafter vaults.

Building code requirements for vault ventilation vary. Some jurisdictions require ventilation of single rafter vaults. Others require that you pack single rafter vaults with insulation and completely close cavities, but provide no ventilation. Building code requirements for vault cavity ventilation take priority over Super Good Cents specifications. Be sure you know local requirements before you start the job.

Energy efficient vaults have a deep rafter cavity (12x or greater) to provide room for R-38 insulation and air space for ventilation. Standard roof vents do not work well in vaulted ceilings. Air entering through the eave vent has a hard time finding a way out at the ridge.

New products make vault ventilation easier. High density insulation batts and blown-in materials make it possible to achieve R-38 in a 2x12 vault and still have a 1-inch air space for ventilation above the batt. New vault vents make it possible to provide a continuous vent at the vault peak.

In Northwest climates, ventilation may help prevent moisture buildup in ceiling insulation and structural members. Ventilation also helps reduce heat buildup in summer. Because excessive heat buildup may shorten the life of composition roofing, some composition roofing manufacturers void their warranty if composition is installed over closed (unventilated) vault cavities. Newer vault ventilation schemes should help keep warranties active.

Figures 4Z-2 and 4Z-3 show methods for venting vaults. Figure 4Z-2 shows methods that provide continuous ventilation. Figure 4Z-3 shows a common method designed for cross ventilation between cavities. This system typically is not as effective as continuous vents.

Open Beam Ceilings

A poorly insulated beam and decking ceiling significantly reduces overall energy performance of the building. If you build open beam ceilings, you probably need to increase conservation levels of other building components to make up for the higher heat loss.

Figure 4Z-4 shows energy efficient variations of the open beam look.

Another option is to use insulated sandwich panels laid over open beams. These are similar to the stress skin panels discussed in the wall and vaulted ceiling sections in this chapter. Insulated sandwich panels are available with a nail base on top for roofing. The inside surface can be finished with your choice of materials.

Figure 4Z-2
EFFECTIVE VAULT VENTILATION DETAILS

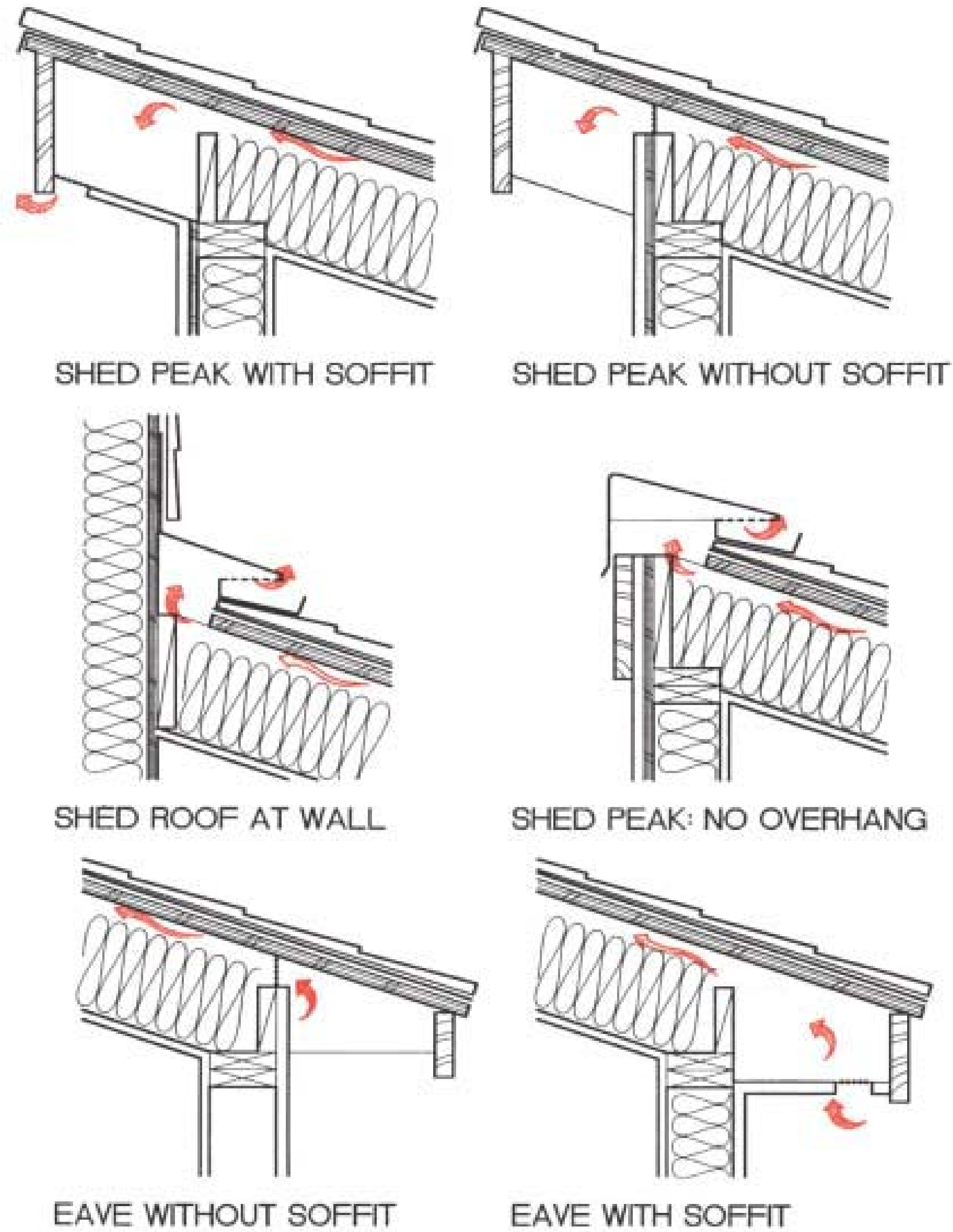
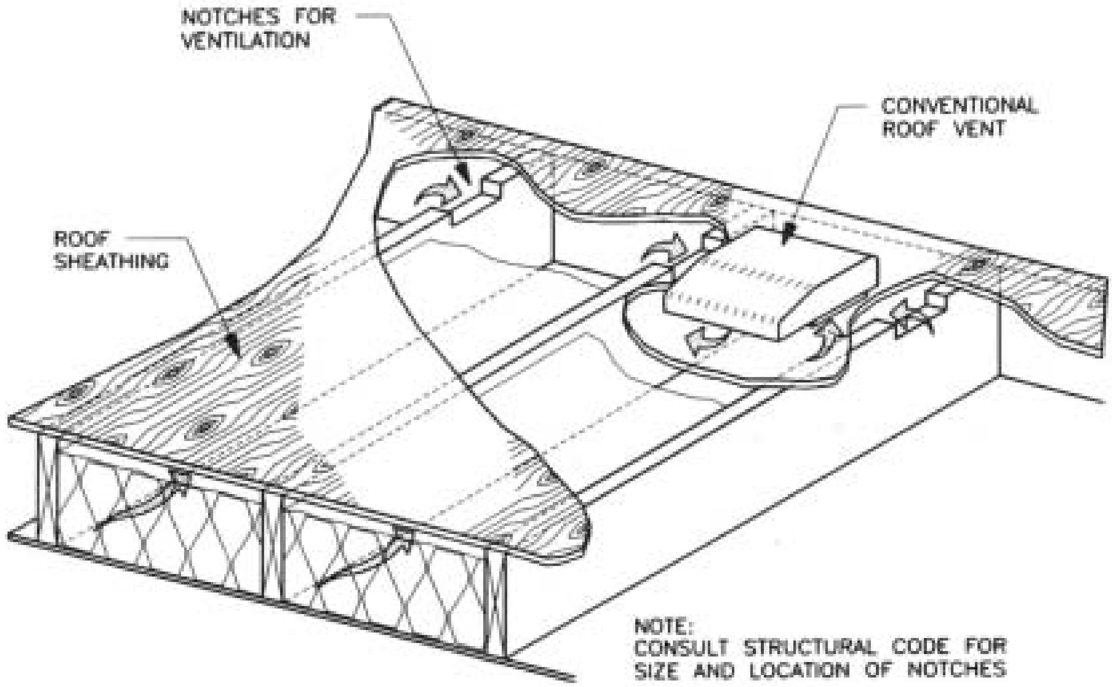


Figure 4Z-3
CONVENTIONAL VAULT VENTILATION



Air Leakage Control in Beam and Decking Ceilings

Decking shrinks after installation, opening thousands of air leakage passageways. Pony walls between beams and beam pockets at walls also are major areas of air infiltration. Some of these leaks can best be addressed during framing. Others may be attended to later in the construction process.

OPENINGS

Window Installation

The Super Good Cents program emphasizes high quality windows. But windows that open perform poorly if installed out of square. Install windows carefully. Check window operation. Make sure windows close tightly against weatherstripping.

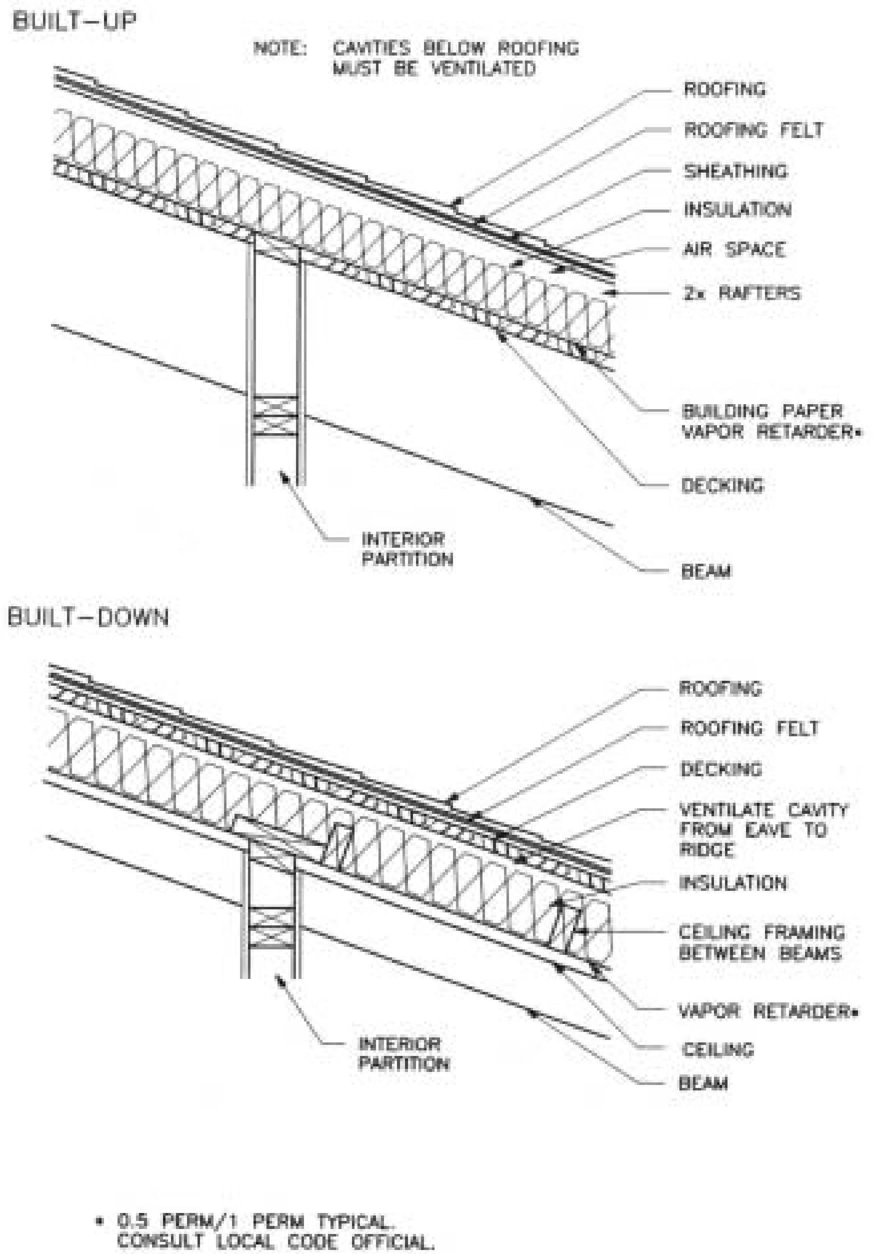
Doors

Make sure exterior and garage passage doors are plumb, level, and square. Make sure they operate smoothly and close tightly against their weatherstripping. Do not forget to adjust the threshold to reduce air leaks at the door bottom.

Skylights

Because of their location high above the room and because of the buoyancy of warm air, skylights can act as chimneys for significant air leakage from the home. Since framers build the skylight curbing and place the skylight on the curbing frame, they have the best shot at sealing cracks around curbing and sealing the skylight to the curbing.

Figure 4Z-4
BEAM AND DECKING CEILINGS



Chapter 5

Electrical Contractor

Besides installing the electrical system for Super Good Cents homes, the electrical contractor may be responsible for heating, lighting, and ventilation systems. If the home plan includes energy efficient lighting options, Super Good Cents specifications affect the type of fixtures and controls that are installed.

Super Good Cents ventilation specifications require higher quality fans and more sophisticated controls than code in many areas. This chapter explores the major differences between Super Good Cents homes and standard construction that affect the electrical contractor.

INSULATING RECESSED FIXTURES IN INSULATED WALLS

Service Panel Location/Panel Insulation

To reduce thermal losses through the wall insulation system, keep the service panel out of walls that will be insulated, if possible. If you must place the service on a wall that will be insulated, Super Good Cents specifications require at a minimum 2-inch rigid (R-10) foam insulation behind the box. It is easiest to place rigid foam into the wall cavity before the service box is installed.

Wall Heaters

If wall heaters are in insulated walls, LTSGC specifications also call for a minimum of R-10 rigid foam behind heating fixtures. It is easiest to place rigid foam into the wall cavity before the heater box is installed.

ZONAL HEATING SYSTEMS

The electrical contractor typically is responsible for installing zonal electric heating systems such as baseboards, wall mounted heaters and radiant heaters. In well insulated, tightly constructed, energy efficient homes, appropriately sized zonal heating systems provide high levels of comfort and efficiency. Zonal systems are not plagued by the 20 to 30 percent duct losses that reduce forced air system efficiency, and zonal systems provide the flexibility to heat only occupied areas of a home while maintaining lower temperatures in unoccupied areas.

Oversizing zonal units wastes money and increases the connected load of a home. Some Super Good Cents utilities have established sizing requirements based on heat load calculations. Check with the local utility before buying equipment.

If you do not know how to do room-by-room heat loss calculations and want to learn, utilities, code jurisdictions, state energy offices, and Extension Service offices can provide instructional materials and forms.

Controls for Zonal Heating Systems in Super Good Cents Homes

1994 LTSGC 3.2.2

1. Wall-mounted thermostats must be installed in each zone. Thermostats mounted on baseboards or wall heaters are not acceptable.
2. Thermostats must have numerical degree settings.
3. Thermostats must be heat anticipating or electronically controlled.

LIGHTING

Special Requirements for Recessed Lights

1994 LTSGC 2.5

Super Good Cents lighting specifications aim to eliminate thermal losses associated with insulation breaks around recessed light fixtures. Recessed lights must be insulated to the full R-value of the ceiling in which they are installed. If full R-value above a fixture is not possible, Super Good Cents specifications allow up to 1 percent of a ceiling area to be insulated with a minimum R-10 rigid foam board.

Because fixtures will be covered with insulation, for fire safety reasons they must be IC (insulation cover) rated.

Acceptable fixtures include:

1. IC rated (but not air leakage tested), double can units sealed around the exterior to be airtight; or
2. IC rated or fluorescent fixtures installed in a site-built “box” that extends the ceiling air barrier above the light fixture; or
3. IC rated fixtures certified under ASTM E-283 to have no more than 2.0 CFM air leakage. The certified fixture shall be tested without trim at 75 Pascals or 1.57 lb/ft^2 pressure difference and have an attached label showing compliance.

Efficient Lighting Option

In some instances the general contractor has an agreement with the participating Super Good Cents utility to install optional energy efficient lighting. Even though it is an option, lighting equipment specifications and design requirements must be met if they are part of the agreement with the utility. Hopefully the general contractor will have informed the electrical contractor about lighting option requirements. Optional equipment may include interior lighting and/or outside/common area lighting for both single and multifamily projects.

Interior Lighting Option

To meet optional interior lighting specifications:

1. One general luminaire with a lamp efficacy of at least 50 lumens per watt (fluorescent fixture) must be installed. The general luminaire must be switched at the room entrance. The general luminaire shall not be capable of accepting medium base Edison incandescent lamps. The color rendition index (CRI) of the lamp shall not be less than 79. The CRI requirement means that common warm /cool white fluorescent lamps do not qualify. Additional luminaires for task lighting or decorative effects need not meet these efficacy and color requirements, but must be controlled by their own switches, independent from the general light.
2. The total wattage of kitchen luminaires must not exceed 2 watts per square foot of kitchen floor area. Wattage of kitchen range hood luminaires is excluded from this budget. If you exceed the kitchen lighting budget, reduce wattages by using more efficient fixtures and luminaires.

Outdoor/Common Area Lighting

Special lamps, fixtures, or controls are needed to meet the optional outside/common area lighting specifications.

1. No more than four luminaires per single family unit or four luminaires per multifamily unit may be installed. Luminaires for multifamily units may be allocated to outdoor or common areas as desired.
2. Luminaires shall have minimum efficacies of 50 lumens per watt (compact fluorescent, metal halide, or high pressure sodium fixtures). Fixtures shall not be capable of accepting medium base Edison incandescent lamps.
3. Outdoor luminaires shall be rated for use in damp locations. Luminaires in outdoor fixtures shall use lamps capable of starting at 0°F.
4. Outdoor luminaires shall be switched at the entrance to the single family or multifamily unit or shall be automatically controlled. Outdoor luminaires

operating on photocells shall be limited to metal halide, high pressure sodium, or compact fluorescents of 9 watts or more. Outdoor luminaires controlled by ultrasonic or infrared motion detectors are exempt from the efficacy requirement.

SUPER GOOD CENTS VENTILATION SYSTEMS

1994 LTSGC 4.3

General Description

Whole House Plus Spot Ventilation

In many Super Good Cents homes, the electrical contractor installs the ventilation system—special exhaust fans and controls that work in concert with fresh air vents installed by the framers. In other cases, central, ducted heat recovery ventilation systems may be installed under the direction of the HVAC contractor.

Ventilation systems in Super Good Cents homes must provide whole house as well as spot ventilation capacity. The overall goal is to install residential and multifamily systems that meet ASHRAE 62-1989, “Standard for Acceptable Indoor Air Quality.” The ASHRAE residential standard prescribes a minimum 15 CFM per person or 0.35 air changes per hour, whichever is greater.

Balanced Systems

Fans installed by the electrical contractor work in concert with fresh air inlets in windows or installed through the wall by framers. As exhaust fans pull stale air out of the home, they pull fresh air in through air inlets.

Fan CFM Requirements

Super Good Cents specifications list minimum (and maximum) fan CFM ratings for achieving prescribed whole house ventilation rates. Required CFM ratings depend on house size and mode of operation (continuous vs. intermittent). In general, intermittent systems require higher fan CFM ratings because run times are shorter; continuous systems require lower fan CFM ratings because run times are longer. Larger residences require higher CFM ratings than smaller residences.

Do Not Overdo It

While it is important to meet minimum ventilation requirements, it is equally important not to overdo it. Too much ventilation creates unnecessary energy penalties and can cause health and safety problems in tight homes with naturally vented combustion appliances.

Controls and Run Times

The designated whole house fan in some homes is automatically controlled to run intermittently at least 8 hours a day. In other homes and many multifamily projects, the whole house fan operates continuously.

Noise

Because of longer run times, quiet (low sone) high quality fans are required to minimize fan noise. If the whole house fan does not have the required sone rating, it must be replaced.

Requirements for sound attenuation between fan canisters and framing and acceptance of remote mount systems are other examples of the Super Good Cents program's emphasis on quiet, high quality ventilation. See Figure 5A. With their low sone ratings and sound attenuation, you should not be able to tell when ventilation fans come on.

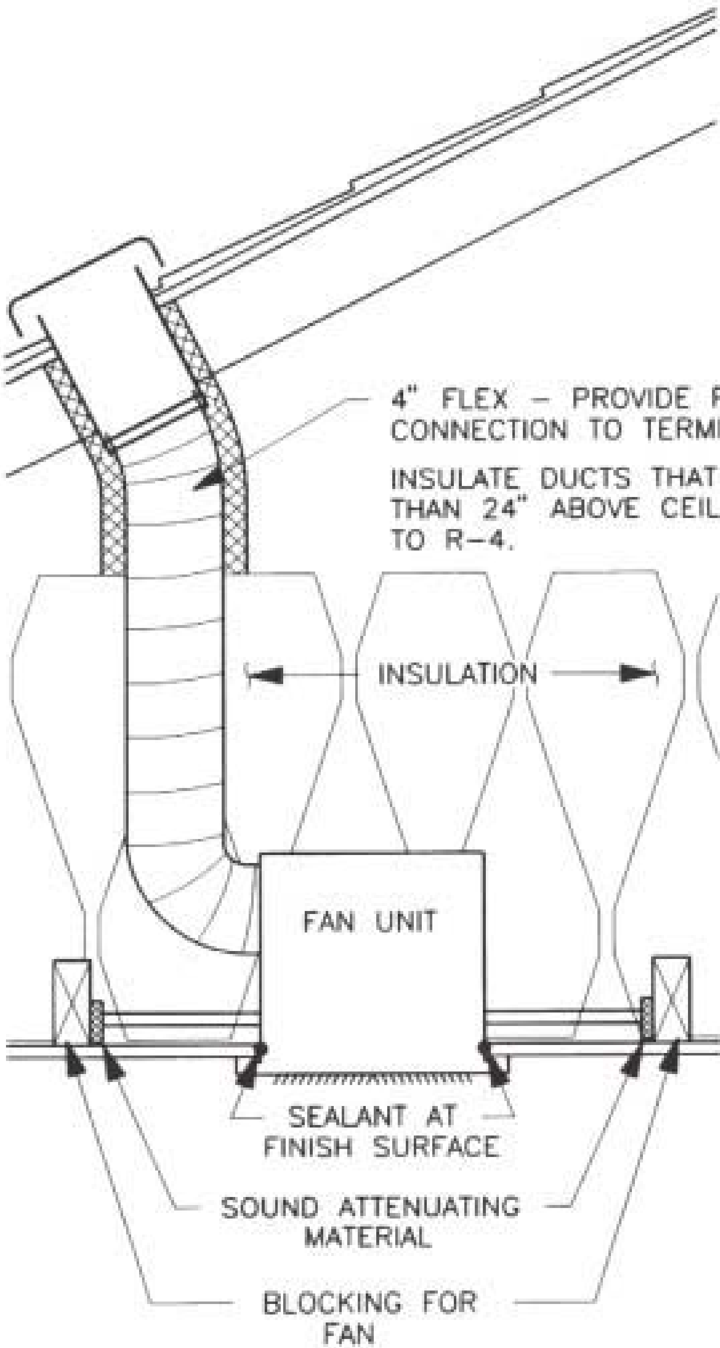
Fan Ducts

Installing the right fan is the first step in achieving effective whole house or spot ventilation. The next step is correct installation of the duct between the fan and outdoors. Super Good Cents specifications address minimum fan duct diameters, maximum duct lengths, maximum number of fittings, and size of termination devices. Most fans installed today lose a third to half of their rated ventilation capacity because the fan duct is too long, the duct material provides too much resistance to airflow, the termination fitting is too small, or there are too many directional changes (fittings) in the duct run. In some cases, screws used to connect the duct to the fan collar are too long and prevent the fan damper from opening.

Many Approaches

Drawings in this chapter show several approved ventilation systems for Super Good Cents homes. Other approaches may be used if locally approved, as long as they meet the intent of program ventilation specifications. Ask the general contractor or Super Good Cents utility representative what ventilation approach will be used, so you can be sure you are purchasing and installing the right equipment.

Figure 5A
SOUND ATTENUATION FOR SURFACE MOUNTED FANS



Whole House Ventilation Specifications

LTSGC 4.3

SUPER GOOD CENTS SONE RATINGS FOR WHOLE HOUSE FANS

Fan Type Systems	Continuous Systems	Intermittent
Surface Mount Fans	1 sone or less	1.5 sones or less
Remote Mount Fans	No requirement	No requirement

Note:

Surface mount - Exhaust fan motors within 4 ft of the pickup grill

Remote mount - Exhaust fan motors more than 4 ft from the pickup grill

Table 5.1
EXHAUST DUCT LENGTH VS. DIAMETER

LTSGC 4.3.1, Table C

Fan CFM 0.25" w.g.	Max. #90° elbows	Flex Duct		Smooth Duct	
		Min. Diameter	Max. Length	Min. Diameter	Max. Length
50	3	4"	25	4"	70
50	3	5"	90	5"	100
50	3	6"	no limit	6"	no limit
80	3	4" not allowed	—	4"	20
80	3	5"	15	5"	100
80	3	6"	90	6"	no limit
100	3	5" not allowed	—	5"	50
100	3	6"	45	6"	no limit
125	3	6"	15	6"	no limit
125	3	7"	70	7"	no limit

For each elbow over three, subtract 10 feet from the maximum duct length.

To prevent condensation inside metal fan ducts and “drip-back” inside the home, fan ducts must be wrapped with a minimum R-4 insulation.

Ventilation Approaches for Multifamily Units (6 or more units)

Any of the following whole house ventilation systems are approved for use in multifamily housing: 1) Multifamily Continuous Ventilation; 2) Multifamily Intermittent Ventilation; or 3) Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System.

Multifamily Continuous Ventilation

Table 5.2 shows minimum (and maximum) fan CFM ratings for continuous ventilation systems in multifamily buildings. Table 5.2 CFM minimums apply when only the whole house fan provides whole house ventilation and separate spot ventilators serve the baths and kitchen.

Table 5.2
CONTINUOUS VENTILATION RATES FOR MULTIFAMILY CONSTRUCTION
LTSGC 4.3, Table A

Number of Bedrooms	Minimum Certified Fan Flow @ 0.25" w.g.	Maximum Certified Fan Flow @ 0.25" w.g.
1	30 CFM	60 CFM
2	50 CFM	75 CFM
3	60 CFM	90 CFM
4	80 CFM	120 CFM

If a whole house fan provides whole house ventilation and continuous spot ventilation in the bathrooms and kitchen, replacing spot ventilation fans at those locations, whole house fan capacity must be sufficient to exhaust a minimum of 20 CFM per bathroom and a minimum of 25 CFM from the kitchen. For example, if a continuous fan provides whole house and continuous spot ventilation in a residence with two baths and a kitchen, the minimum whole house fan capacity is 65 CFM.

Multifamily Intermittent Ventilation

Intermittent whole house ventilation systems in multifamily residences must be sized to provide 1.5 times the fan capacity in Table 5.2. A central intermittent system may replace spot ventilators if the central system is sized to meet minimum intermittent spot ventilation requirements: 50 CFM per bathroom and 100 CFM for the kitchen.

Controls for intermittent systems include a 24-hour timer with a manual switch capable of setting two ventilation periods for a total minimum ventilation period of 8 hours per day. If the whole house fan provides whole house and spot ventilation, the fan must be controlled in parallel by a 24-hour timer and manual switches in the baths and kitchen.

Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System

The ventilation system may be integrated with the heating/cooling system only if each multifamily unit has a separate forced air system. Installation of this type of system needs to be coordinated with the HVAC contractor. The electrical contractor may provide a 24-hour timer, the exhaust fan, and a 24-volt control circuit for the furnace fan and motorized damper. The HVAC contractor may provide the final furnace and damper hookups.

The whole house exhaust fan must meet multifamily CFM requirements (continuous or intermittent), be controlled by a 24-hour timer with a manual override switch, and be set to provide a minimum ventilation period of 8 hours per day. The 24-hour timer also controls the furnace fan and a motorized damper on a duct that brings fresh air to the furnace return plenum. When the timer calls for ventilation, the exhaust fan comes on, the motorized damper opens, and the furnace fan comes on. Stale air is exhausted from the residence and fresh air is distributed throughout the home. See Figures 5D-1, 5D-2 and 5D-3.

Whole House Ventilation Approaches for Single Family Construction (Five units or less)

Four different approaches are approved for whole house ventilation in single family construction: 1) Single Family Integrated Spot and Whole House Ventilation; 2) Single Family Continuous Ventilation; 3) Single Family Discrete Spot and Whole House Ventilation; and 4) Single Family Ventilation Integrated With Forced Air System.

Table 5.3 gives minimum flow rates for intermittent systems. For continuous systems, minimum flow for the home is 20 CFM per bathroom plus 25 CFM for the kitchen.

Table 5.3
SINGLE FAMILY INTERMITTENT VENTILATION

LTSGC 4.3.1, Table B

Number of Bedrooms	Minimum Certified Fan Flow @ 0.25" w.g.	Maximum Certified Fan Flow @ 0.25" w.g.
2 or less	50 CFM	75 CFM
3	80 CFM	120 CFM
4	100 CFM	150 CFM
5	120 CFM	180 CFM

Single Family Integrated Spot and Whole House Ventilation (Intermittent)

A whole house fan does double duty as a spot ventilator. The spot ventilation control turns on the fan whenever spot ventilation is needed. A 24-hour timer turns on the fan for the required 8-hour ventilation period each day. See Figures 5B-1 and 5B-2.

Single Family Continuous Ventilation

A whole house fan with pickups in each bath and the kitchen runs continuously. The fan is sized to provide a minimum of 20 CFM per bathroom and 25 CFM for the kitchen, but no more than 0.5 air changes per hour.

Another variation is a whole house fan that runs continuously to provide whole house ventilation and also provides spot ventilation for the bathroom in which it is installed. The other bathrooms and kitchen are served by separate spot ventilators. The whole house fan is sized to provide the greater of the minimum spot ventilation rate for the bathroom (50 CFM) or the minimum continuous ventilation rate for the whole house (20 CFM per bath plus 25 CFM for the kitchen).

Single Family Discrete Spot and Whole House Ventilation (Intermittent)

The whole house fan, controlled by a 24-hour timer and manual switch, is completely separate from the spot ventilators. See Figures 5C-1 and 5C-2.

Single Family Ventilation Integrated With the Forced Air System (Intermittent)

If the home has a forced air system, the ventilation system may be integrated with the hearing/cooling system. Installation of this system needs to be coordinated with the HVAC contractor. The electrical contractor may provide the 24-hour timer, the whole house exhaust fan, and a 24-volt control circuit for the furnace fan and

Figure 5B-1
INTEGRATED SPOT/WHOLE HOUSE VENTILATION SYSTEM

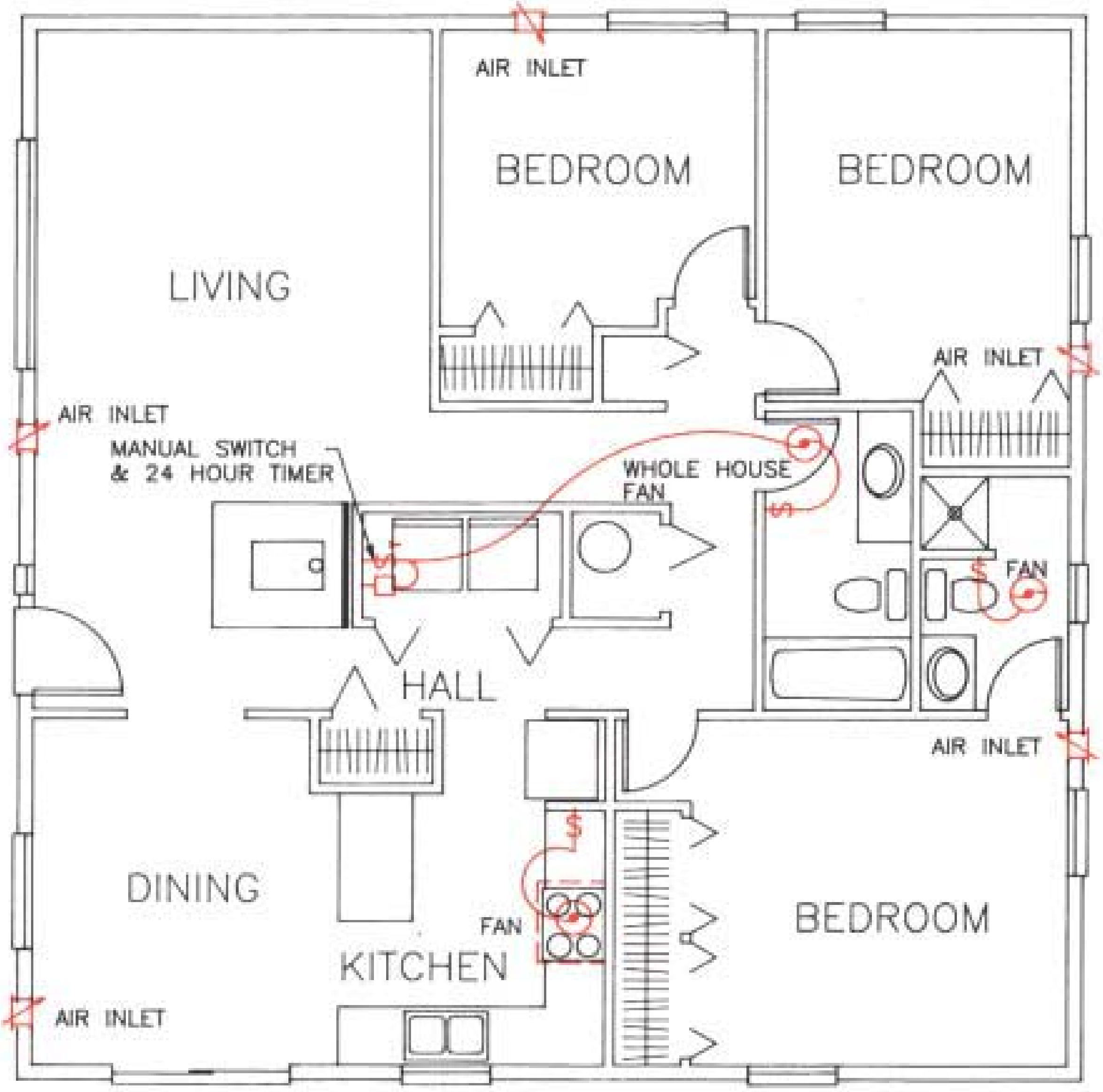


Figure 5B-2

CONTROL WIRING SCHEMATIC: INTEGRATED SPOT/ WHOLE HOUSE VENTILATION SYSTEM

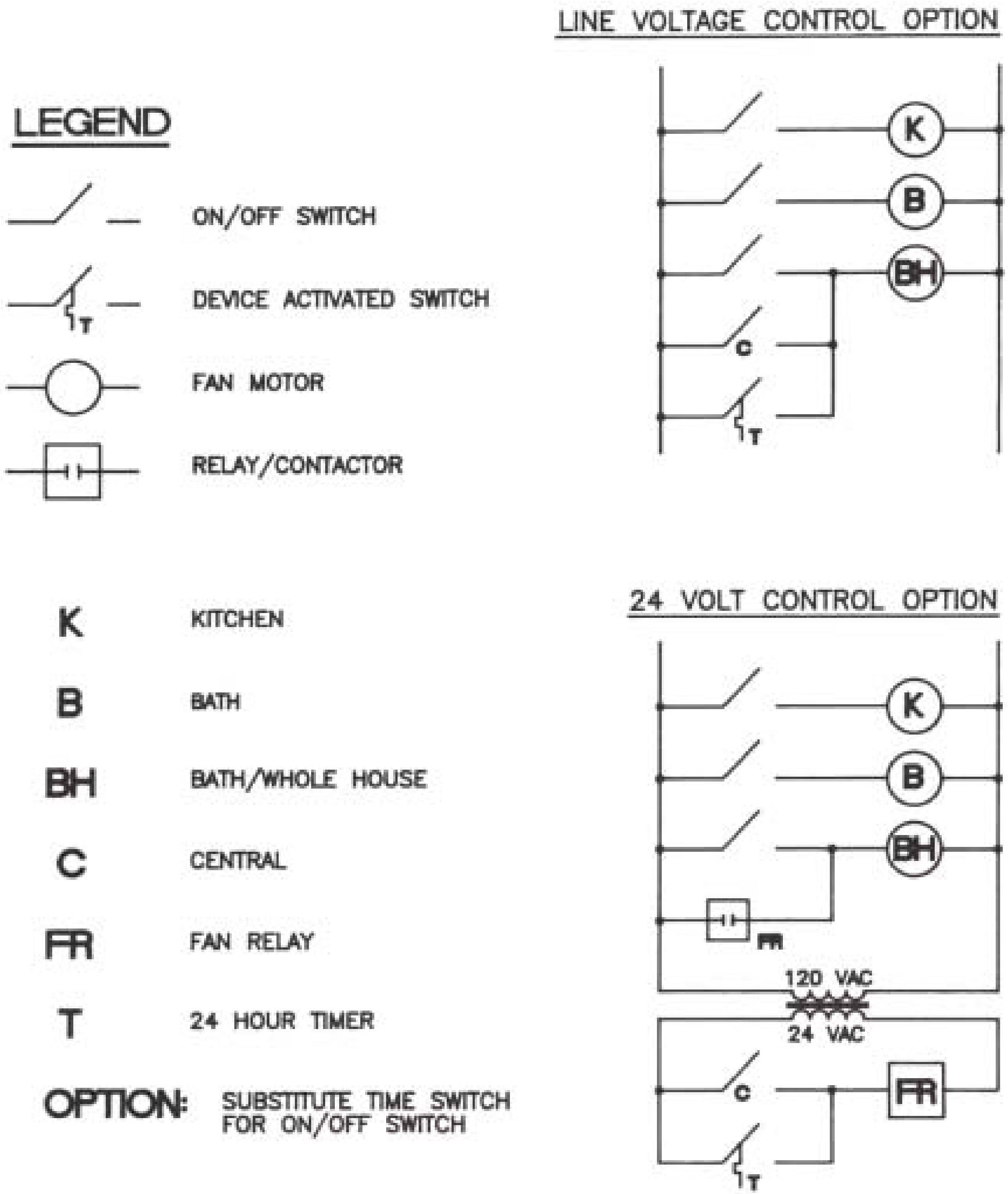
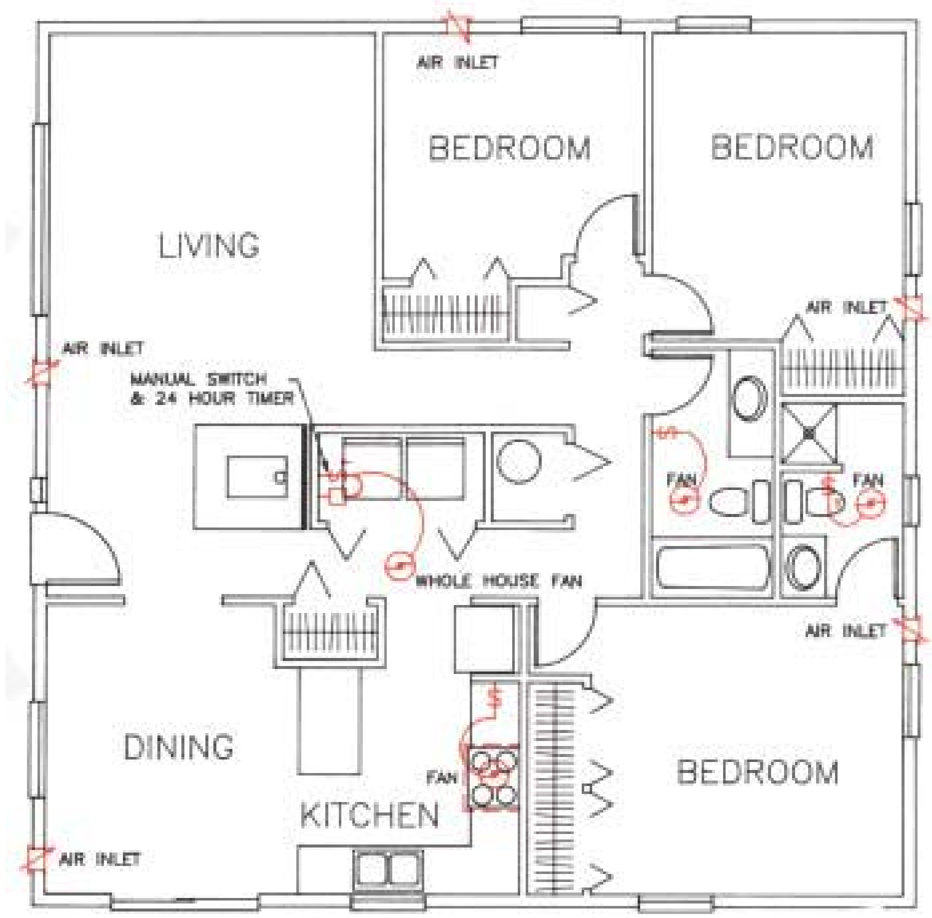


Figure 5C-1
DISCRETE SPOT/WHOLE HOUSE VENTILATION SYSTEM



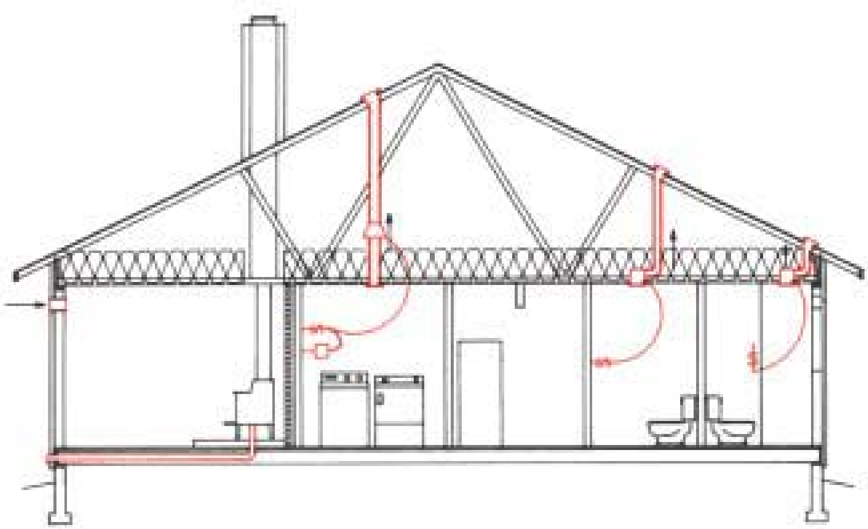
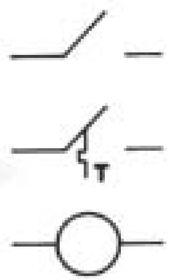


Figure 5C-2
CONTROL WIRING SCHEMATIC: DISCRETE SPOT/ WHOLE HOUSE VENTILATION SYSTEM

LEGEND



ON/OFF SWITCH

DEVICE ACTIVATED SWITCH

FAN MOTOR

WH WHOLE HOUSE

K KITCHEN

B BATH

C CENTRAL

T 24 HOUR TIMER

OPTION: SUBSTITUTE TIME SWITCH FOR ON/OFF SWITCH

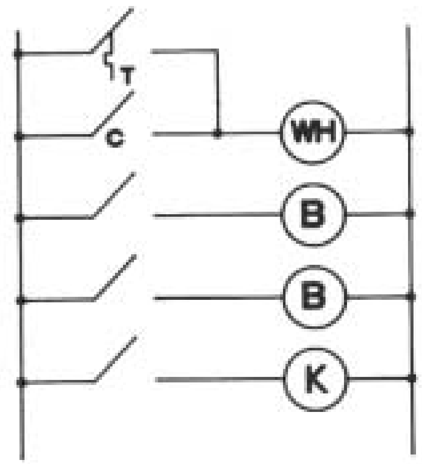
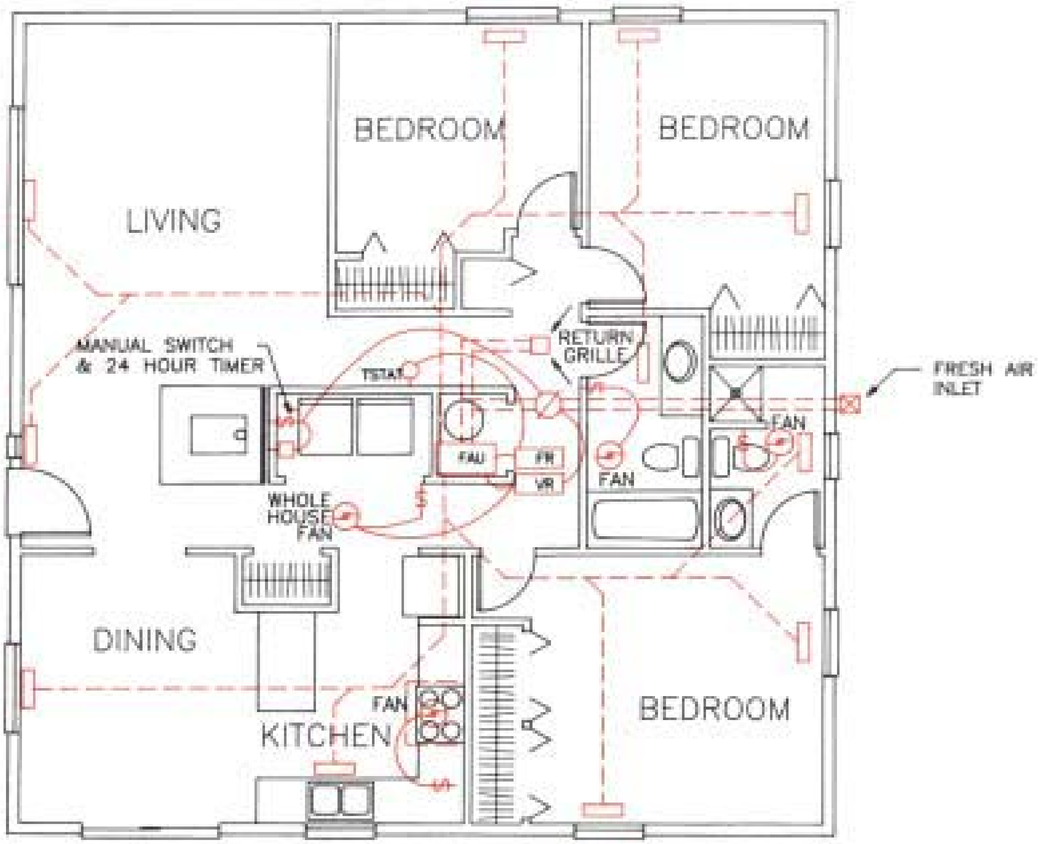


Figure 5D-1
WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING



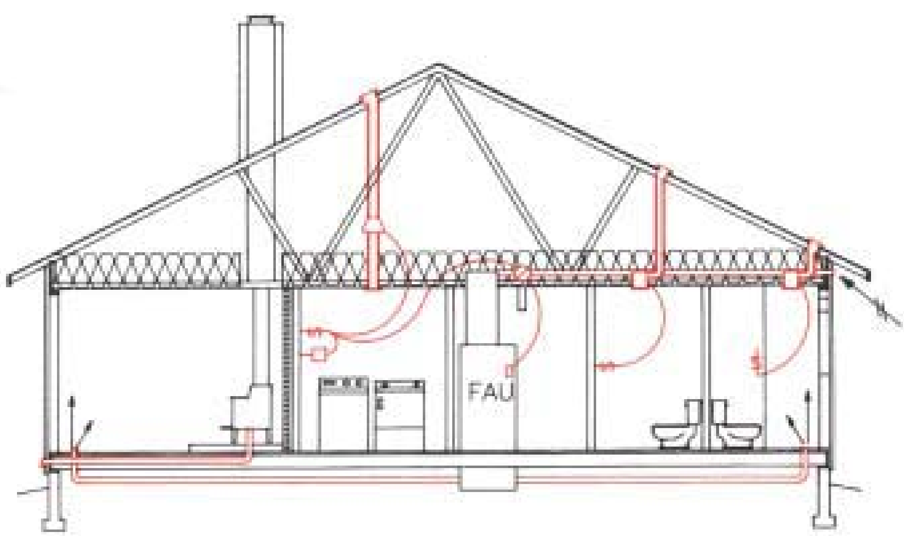


Figure 5D-2

EXAMPLE 1 CONTROL WIRING SCHEMATIC: WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING

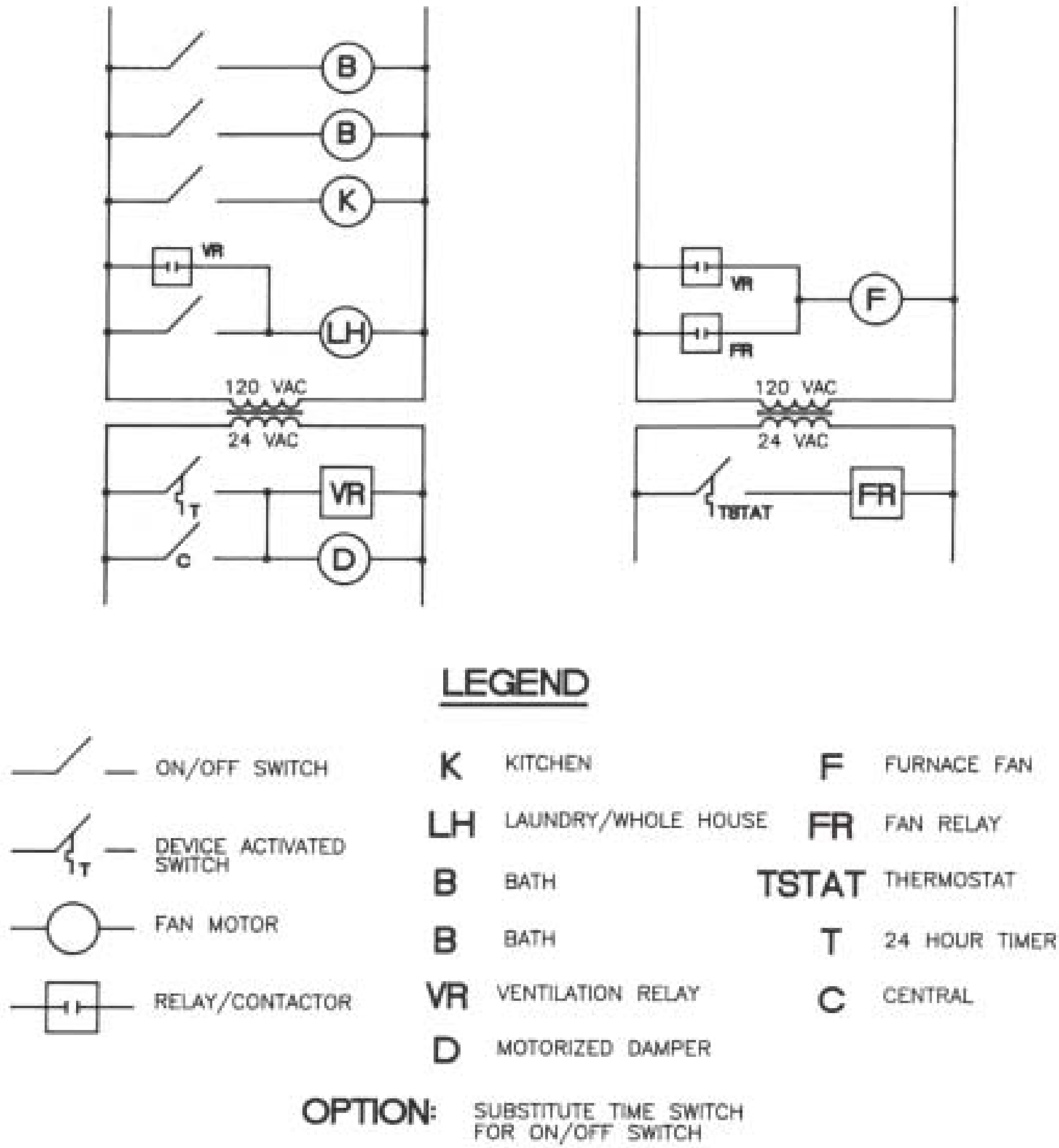
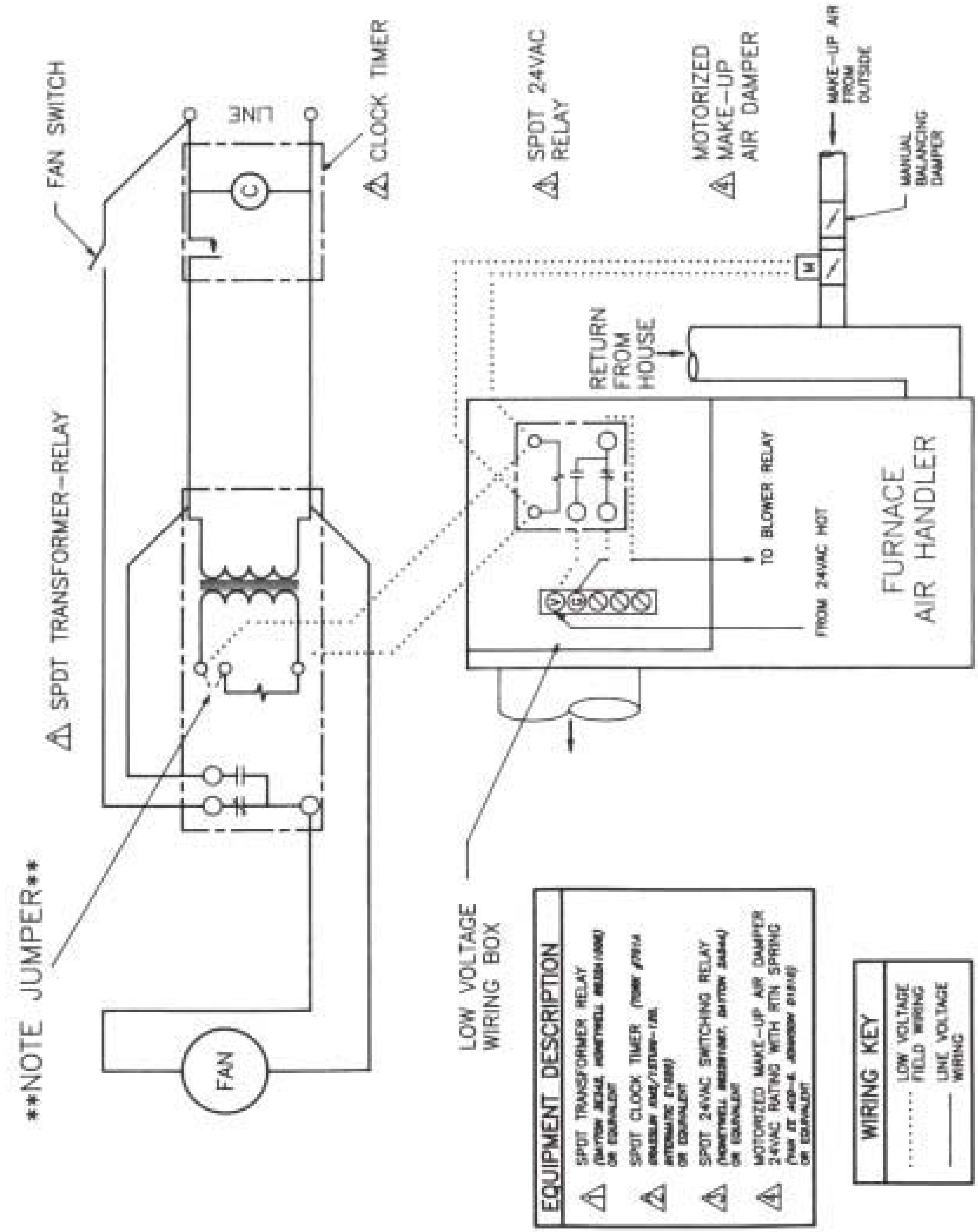


Figure 5D-3

EXAMPLE 2 CONTROL WIRING SCHEMATIC: WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING



motorized damper. The HVAC contractor may provide the final furnace and damper hookups.

The whole house exhaust fan must meet CFM requirements (continuous or intermittent), be controlled by a 24-hour timer with a manual override switch, and be set to provide a minimum ventilation period of 8 hours per day. The 24-hour timer also controls the furnace fan and a motorized damper on a duct that brings fresh air to the furnace return plenum. When the timer calls for ventilation, the exhaust fan comes on, the motorized damper opens, and the furnace fan comes on. Stale air is exhausted from the residence and fresh air is distributed throughout the home. See Figures 5D-1, 5D-2, and 5D-3.

Spot Ventilation in Super Good Cents Single Family and Multifamily Construction

Table 5.4
SUPER GOOD CENTS SPOT VENTILATION REQUIREMENTS

LTSGC 4.3.4, Table D

Location	Intermittent Spot Ventilation	Continuous Spot Ventilation
Each bath	50 CFM	20 CPM
Kitchen	100 CFM	25 CFM

While some building codes allow operable windows to substitute for spot fans in bathrooms and kitchens, the Super Good Cents program does not. Mechanical exhaust to the outside is required.

Spot ventilation fans may be wired to a light switch or to a separate on/off control. Spring wound or electronic timer switches are recommended, but not required. Timer switches have the double advantages of automatic shut-off and allowing ventilation to continue beyond the time the room is in use.

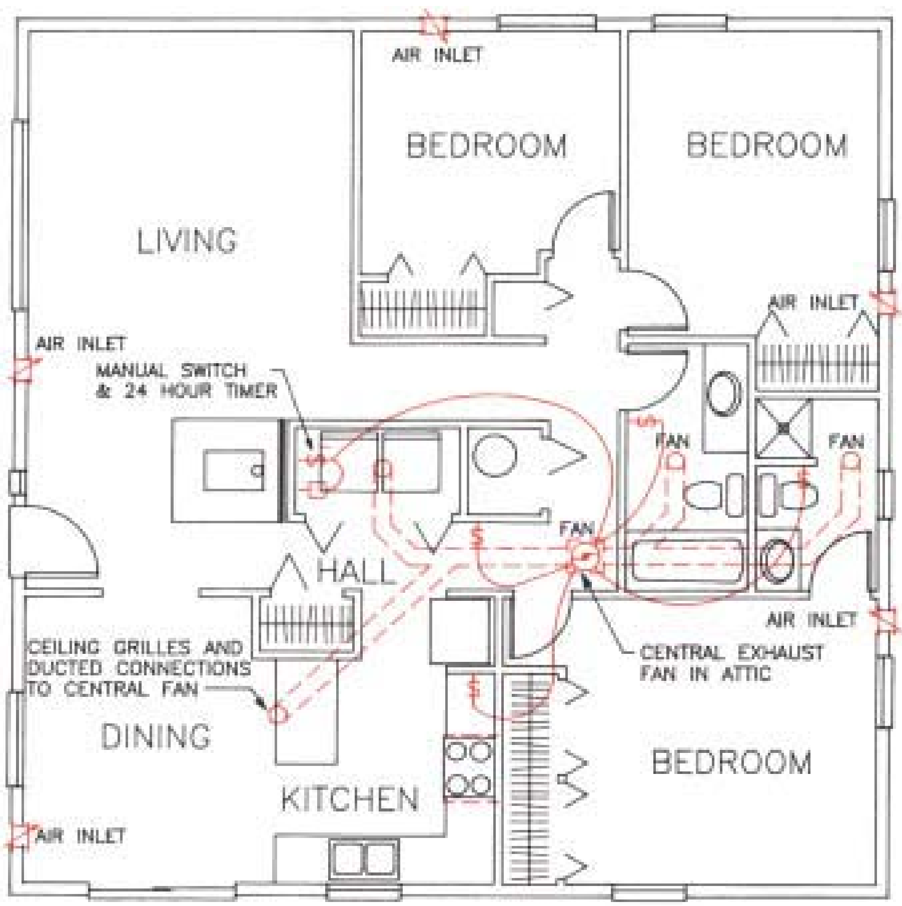
A recirculating range hood alone does not meet kitchen spot ventilation standards. Recirculating range hoods must be accompanied by a separate exhaust pickup in the kitchen.

In some cases a spot ventilator is upgraded to do double duty as the whole house fan. In that case, the fan is controlled in parallel by two devices: the manual switch at the spot fan location and a centrally located 24-hour timer with a manual switch.

Utility room fans are not required by the Super Good Cents program, but they are good practice and are required by some building codes. Utility room fans exhaust moisture and fumes emitted by cleaning compounds stored in utility areas.

Figures 5E-1, 5E-2, 5F-1, 5F-2, and 5G show other ventilation systems the electrical contractor may be called on to wire or install.

Figure 5E-1
REMOTE CENTRAL WHOLE HOUSE VENTILATION SYSTEM



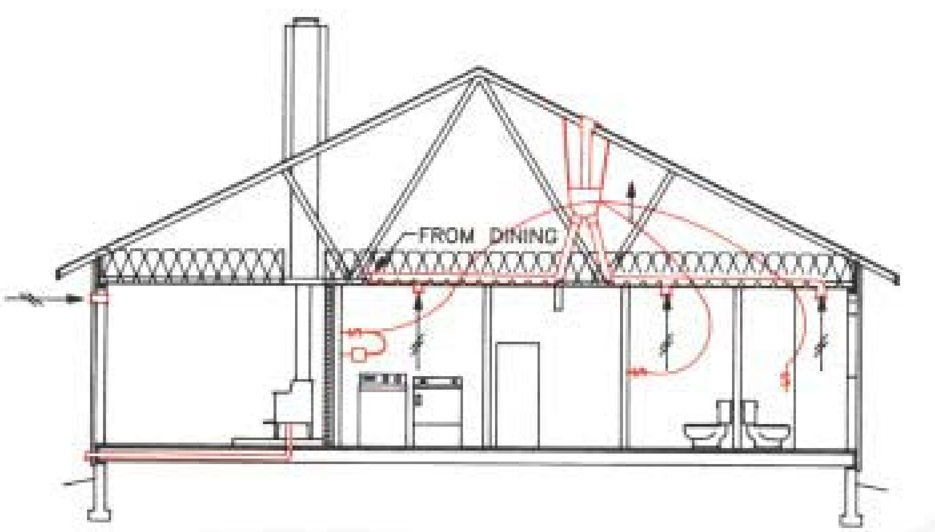


Figure 5E-2

CONTROL WIRING SCHEMATIC:
REMOTE CENTRAL WHOLE HOUSE VENTILATION SYSTEM

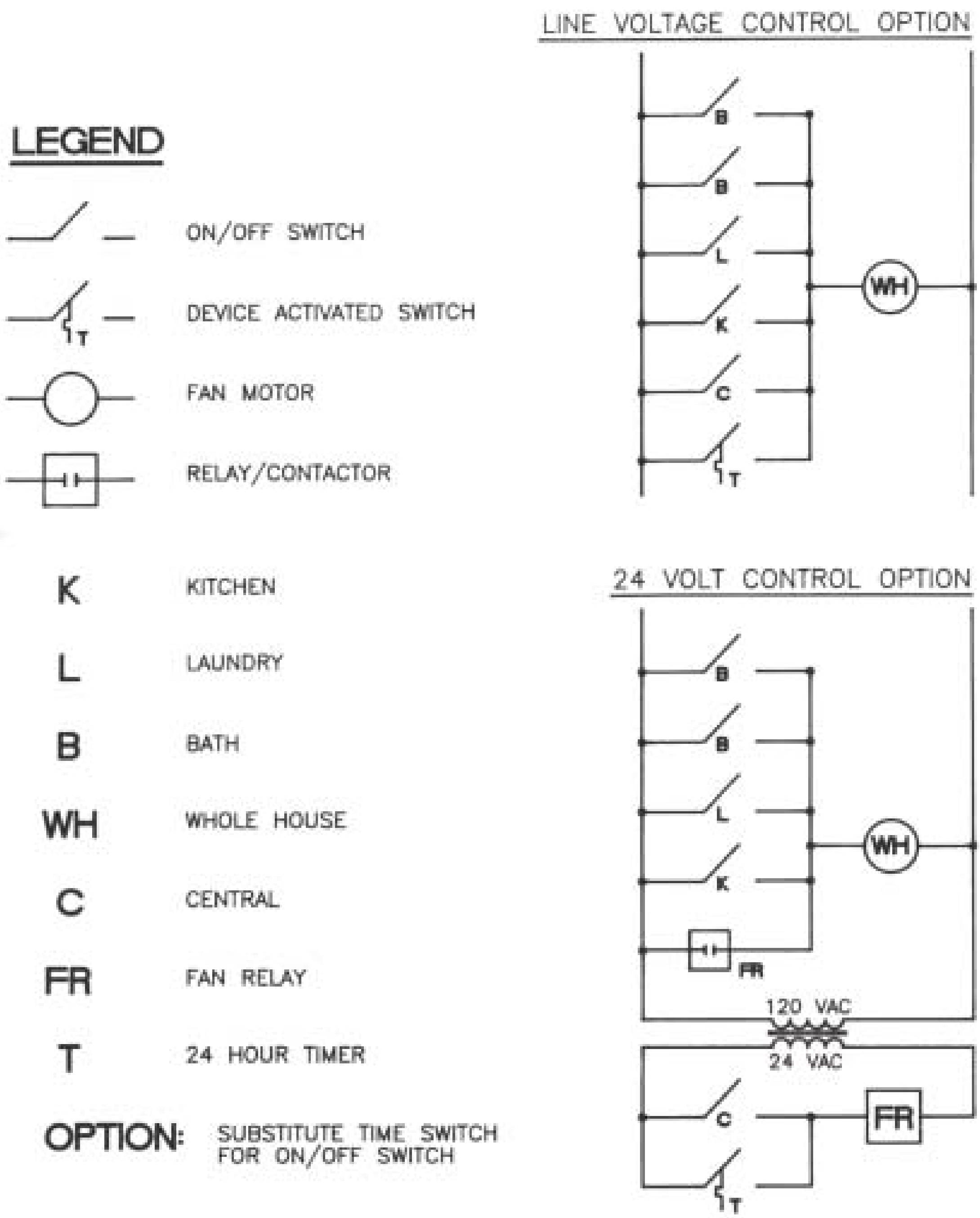
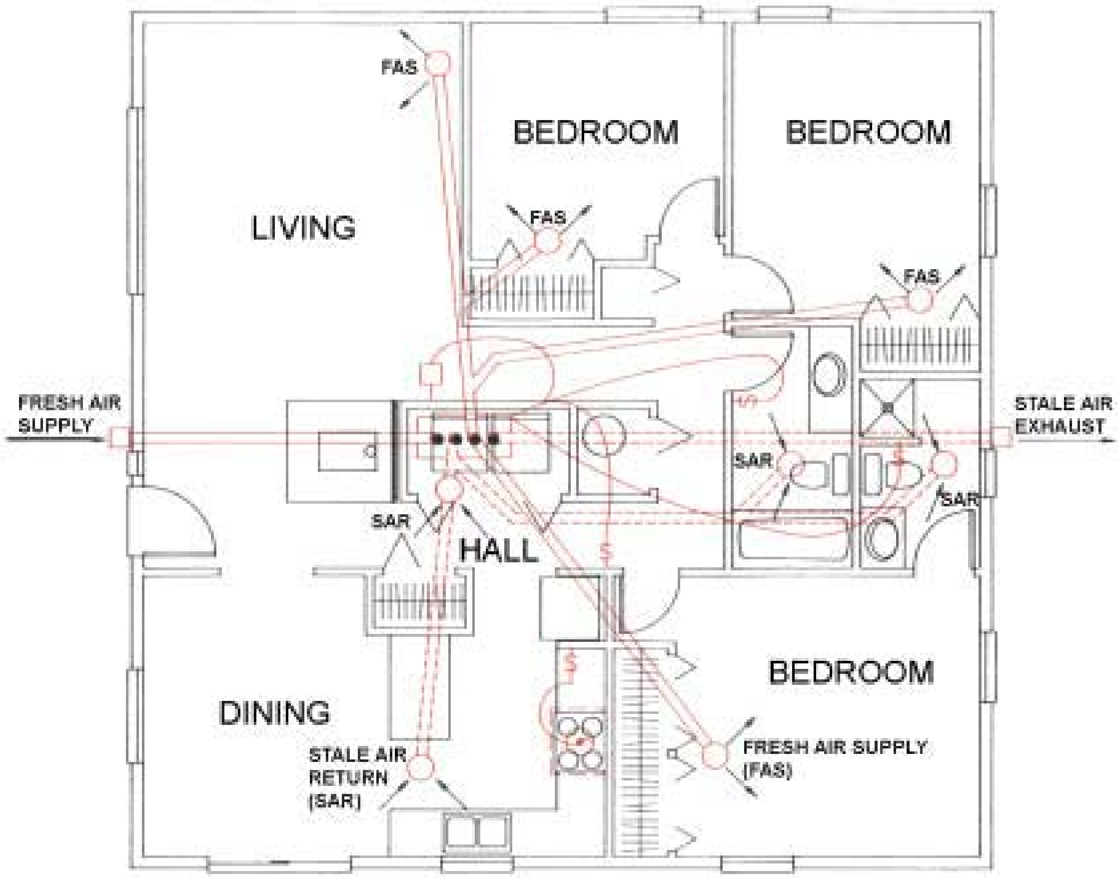


Figure 5F-1
AIR-TO-AIR HEAT EXCHANGER VENTILATON SYSTEM



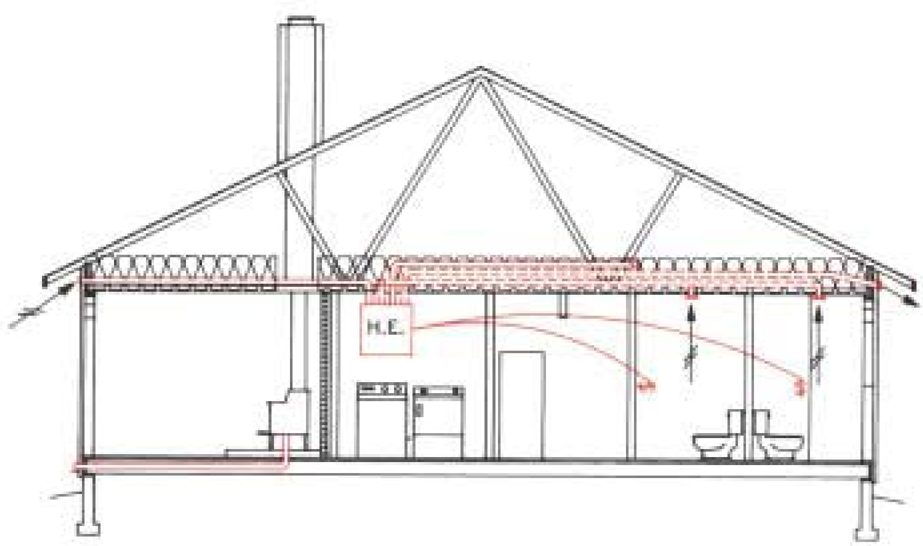
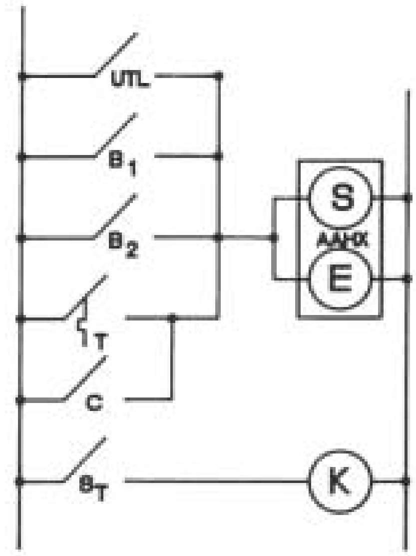


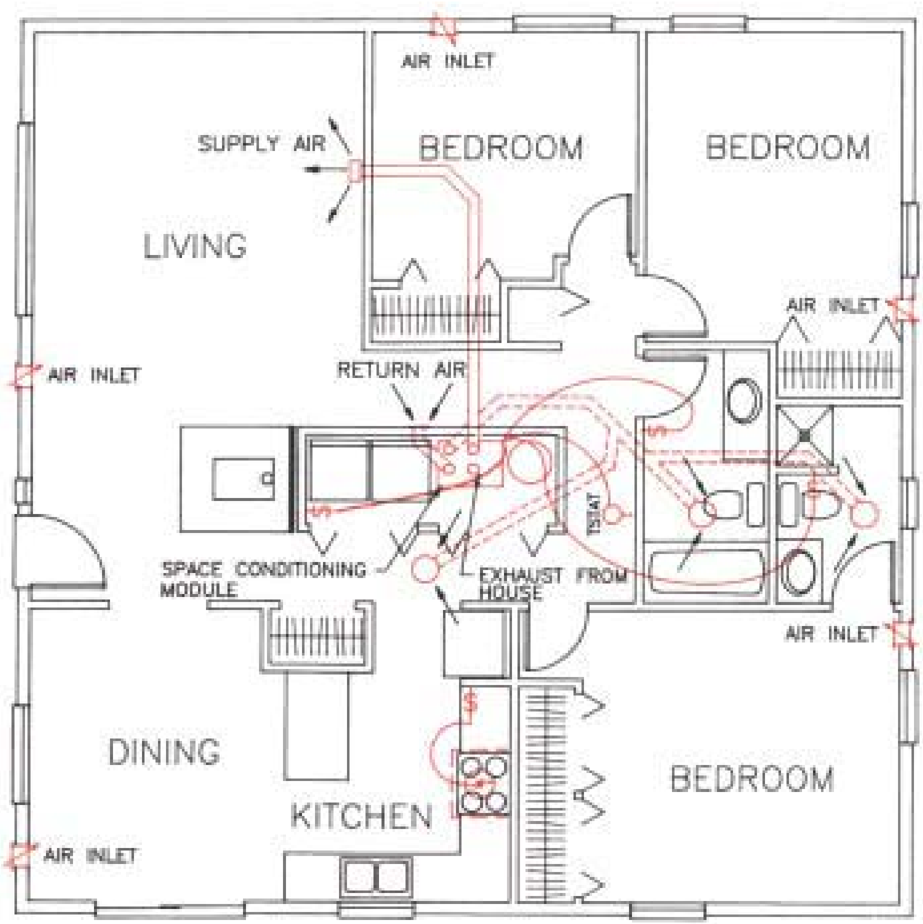
Figure 5F-2
CONTROL WIRING SCHEMATIC:
AIR-TO-AIR HEAT EXCHANGER VENTILATION SYSTEM

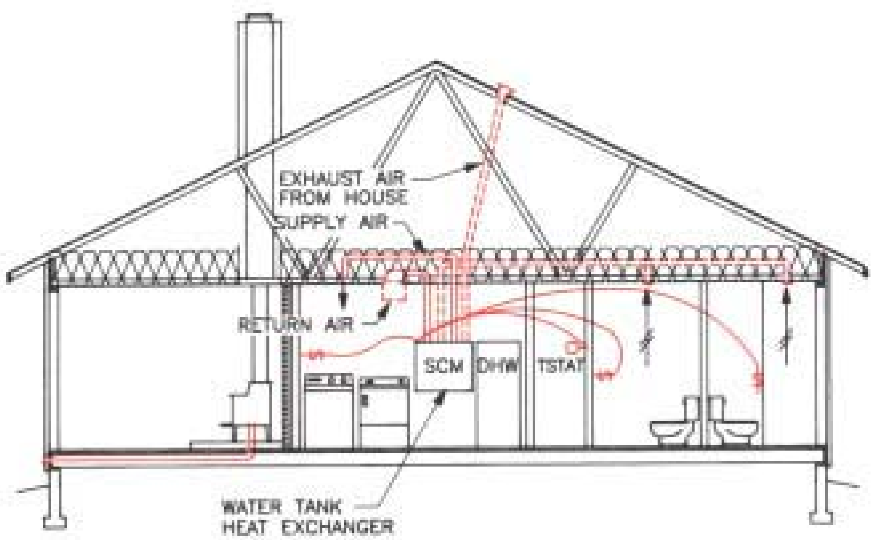


LEGEND

Symbol	Meaning
	MANUAL OFF/ON SWITCH
B_T	MANUAL TIMER SWITCH
	DEVICE ACTIVATED SWITCH
	FAN MOTOR
T	24 HOUR TIMER
K	KITCHEN
S	FRESH AIR SUPPLY
E	STALE AIR EXHAUST
AAHX	AIR TO AIR HEAT EXCHANGER
B_1	BATH 1
B_2	BATH 2
C	CENTRAL MANUAL CONTROL
UTL	UTILITY

Figure 5G
EXHAUST AIR HEAT PUMP VENTILATION SYSTEM





Chapter 6

Plumbing Contractor

The plumbing contractor affects energy efficiency of a building by selecting the hot water heater and fixtures and by making plumbing penetrations.

PURCHASING AND INSTALLING WATER HEATERS

Water heating accounts for 25 percent of energy use in a typical residence. In Super Good Cents homes, the water heater often is the largest single user of electrical energy. An energy efficient water heater reduces energy use and water heating costs.

Water heaters and other appliances are tested and rated by a national program to improve appliance efficiency.

Super Good Cents Electric Water Heater Performance Standards

1994 LTSGC 2.7

The 1994 Super Good Cents program requires that water heater energy efficiency exceed federal minimum performance standards. Your Super Good Cents representative can supply you with the most current list of acceptable water heaters. To meet 1994 Super Good Cents specifications, water heaters with a 0- to 59-gallon capacity must have an energy factor of 0.93; 60- to 120-gallon water heaters must have an energy factor of 0.91.

Electric Water Heater Installation Requirement: Insulated Pad

Electric water heaters on uninsulated concrete slabs and water heaters on uninsulated platforms in garages must have a non-compressible insulating pad of R-10 or better below them. Make sure the pad is onsite before the tank is ready to be plumbed in.

The R-10 pad is typically 2 inches of extruded polystyrene foam insulation (typically the colored foam insulations—blue, pink, and green). If you use expanded polystyrene (beadboard), you will need a 3-inch pad since beadboard has a lower R-value per inch. Most beadboard has less compressive strength than extruded polystyrene and may provide less stability than the blue, pink, and green products. However, beadboard with a density of 2 lb per ft^2 has compressive strength comparable to extruded polystyrene and is suitable.

It is recommended, but not required, that water heaters be located within the heated space.

Combustion Water Heaters

1994 LTSGC 2.6.2

The Super Good Cents program does not have performance standards for combustion water heaters, but important indoor air quality standards affect the type of combustion unit that may be used. Its location determines what type of unit the Super Good Cents program allows.

Combustion water heaters located inside the living area of the home must be the sealed combustion type. They have outside combustion air ducted to the firebox. They also must be directly vented to the outside with no possibility of combustion products mixing with indoor air.

Combustion water heaters located outside the living area (in a garage, for example) do not have to be sealed combustion units. However, recent research shows that leaks at furnace cabinets in garages can pull pollutants from garages into homes. Using a sealed combustion unit, or at a minimum, an induced draft water heater, is a good idea even in garages.

EXHAUST AIR HEAT PUMPS

Exhaust air heat pumps (EAHPs) are heat pump water heaters that recover heat in stale exhaust air to heat household water. They also ventilate the home. EAHPs are usually installed by heating/cooling contractors, but they have special plumbing needs. If house plans call for an EAHP, contact the general contractor for plumbing requirements before you complete your bid.

SHOWERHEADS

Efficient showerheads are a highly cost-effective way to conserve water and water heating energy, and are the perfect complement to an efficient hot water tank. The 1994 Super Good Cents program does not specify efficient showerheads because, in general, they are required in Northwest building codes.

The flow rate of a showerhead has a major influence on the amount of energy used to heat water. Efficient showerheads use 2.5 gallons of water or less per minute.

Flow rate information is available from the distributor or manufacturer. Although many showerheads have low flow rates, not all showerheads are highly rated by consumers. Ask around or consult consumer tests for the most popular models.

PIPE INSULATION

High levels of floor insulation in the Super Good Cents program allow less heat loss from living areas to the crawl space. A cooler crawl space means a greater chance for pipes to freeze. Pipe insulation or other methods of freeze protection are not always required by the Super Good Cents program, but they are a good idea (and may be required by local codes).

The best way to prevent pipe freezing is to locate pipes directly under the subfloor so that floor insulation is between the pipes and the crawl space. That way heat from the house keeps pipes warm even in the coldest weather.

Keep pipe runs in exterior walls to a minimum. Pipes are less likely to freeze if high R-value insulation is placed between them and the exterior wall.

AIR LEAKAGE CONTROL

Plumbing walls contain penetrations to the crawl space for water and drain lines and penetrations to the attic for the vent stack. The penetrations create hidden air leakage routes. They are called "thermal bypass routes" because they can create cold chimneys in interior walls for airflow between the attic and crawl space. Air leakage through plumbing walls bypasses the home's insulation system.

Insulation in the floor or ceiling does not stop air currents moving through the plumbing wall. Only specific air sealing measures can stop air leakage.

Care by the plumber can significantly reduce air leakage at plumbing penetrations.

Big holes are hard to seal. Cut holes for plumbing penetrations carefully to closely match the size of the pipe. It makes air sealing easier.

Sealing the Tub Penetration

It is hard to seal the tub penetration. But in energy efficient homes, it can be the largest single leak in the whole building. Figures 6A and 6B show ways to seal the tub penetration.

Air sealing the tub penetration cuts off a significant air path from the unheated crawl space into interior plumbing walls. If the tub is mounted on an accessible platform, with the p-trap above the floor, the tub penetration is much easier to seal.

Sealing Vent Stacks

Vent stacks tend to expand and contract because of temperature differences along the stack. Flexible gaskets are the most effective seals for stack penetrations.

Place gaskets over the hole, seal them to the top plates, and cut them out to fit snugly against the stack. In some cases you may just slip gaskets over pipes as you plumb the area. The air tightening specialist or general contractor can complete sealing.

Figure 6C shows how to seal a vent stack penetration to the attic.

Other sealants for stacks include oakum and elastic, flexible sealants, and caulks that will not break the air seal as the stack expands and contracts.

TIP: Gaskets are cleaner.

Other Plumbing Penetrations

Most other plumbing penetrations are small. They can be adequately sealed with caulk or expanding foam. Sealing penetrations helps eliminate air leakage bypass routes and improves comfort and energy efficiency of the home.

Figure 6A
GASKET AT TUB PENETRATION

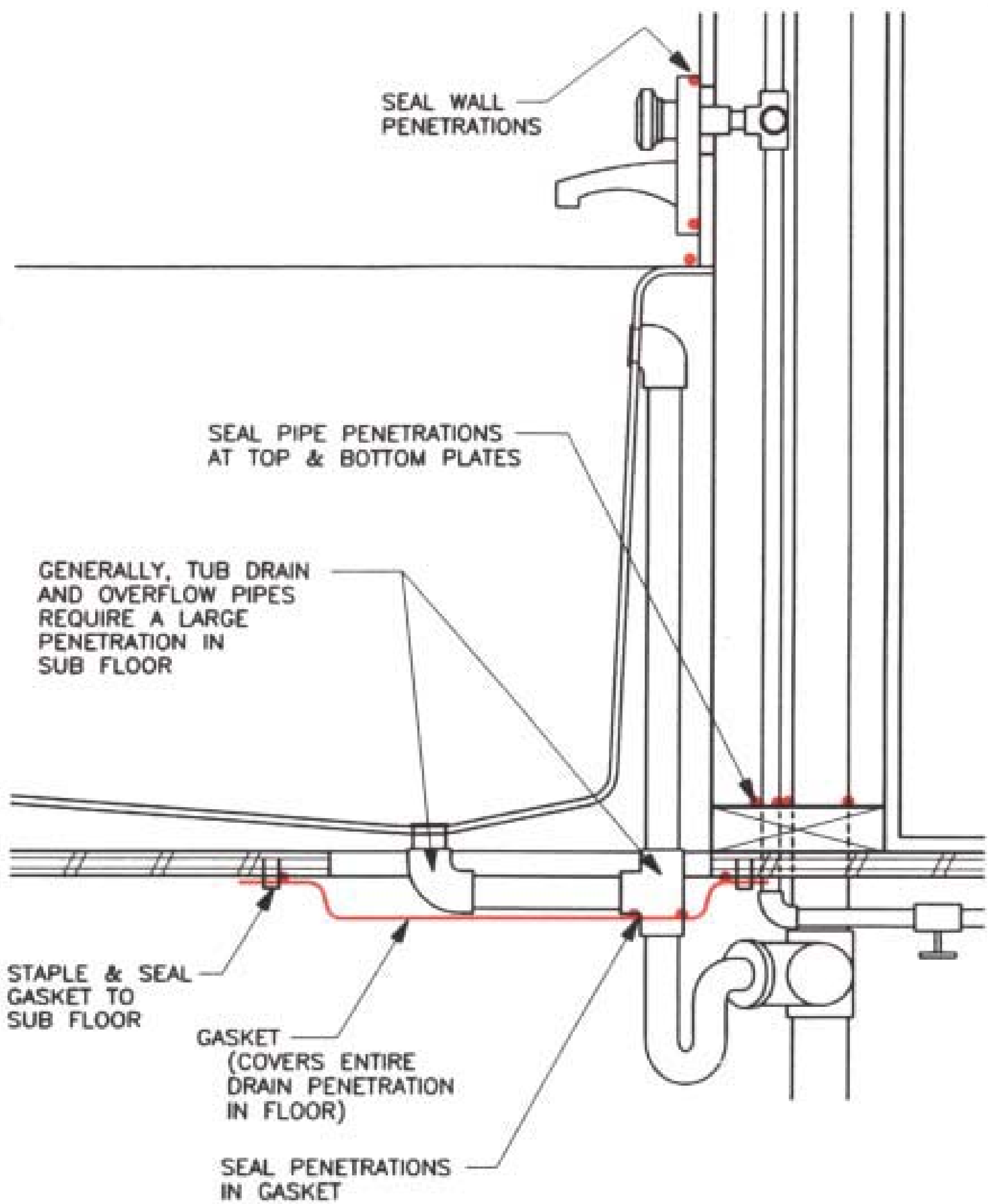


Figure 6B
BOXED-IN TUB PENETRATION

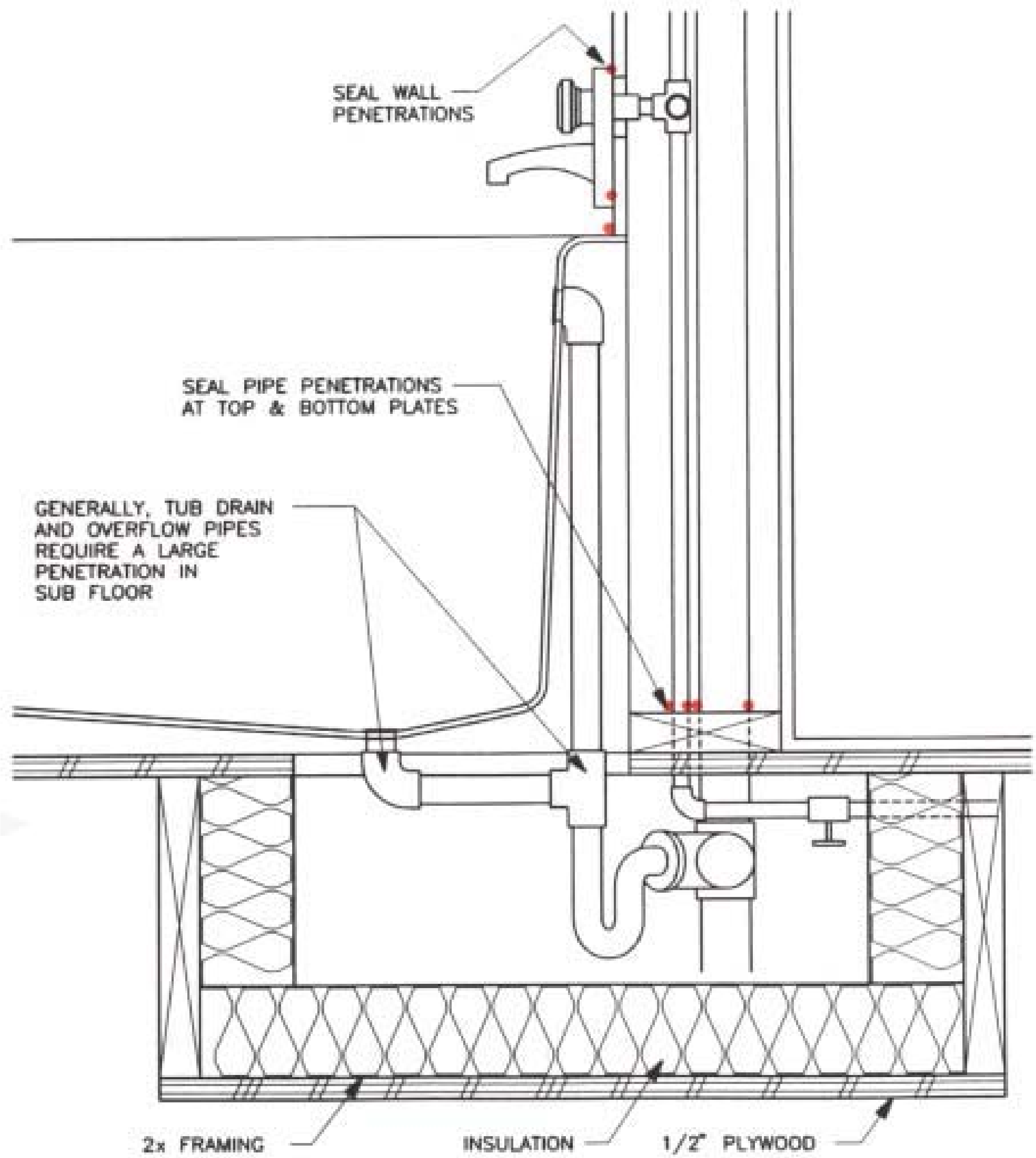
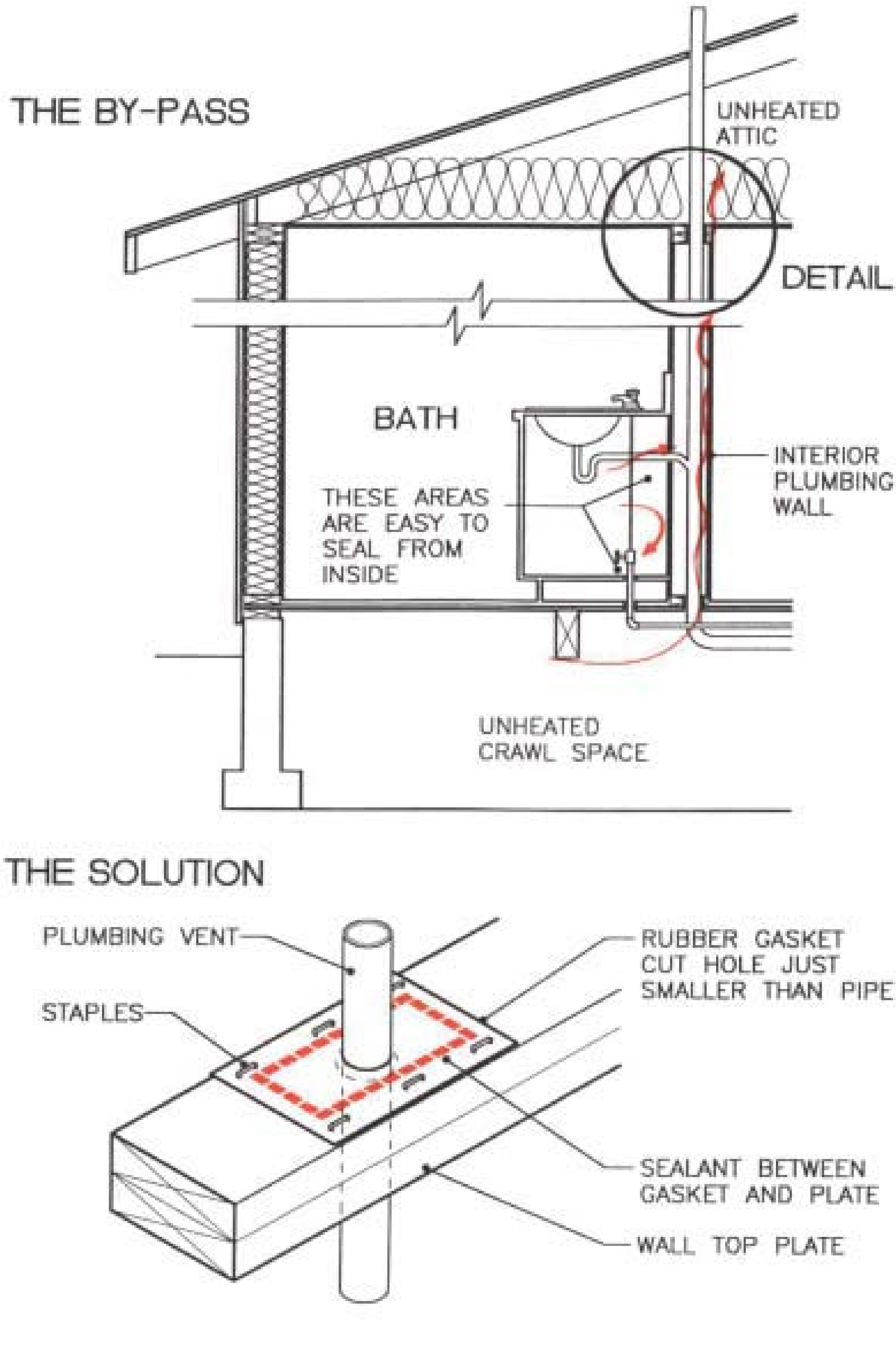


Figure 6C
GASKET AT VENT STACK PENETRATION TO ATTIC



Chapter 7

HVAC Contractor

Super Good Cents specifications that affect the HVAC contractor focus on heating system controls, forced air system installation, and ventilation systems. In some cases, the HVAC contractor is responsible for integrating the ventilation system with central forced air heating.

The HVAC contractor also may be responsible for installing ducted heat recovery ventilation systems. Super Good Cents design standards for ventilation systems specify controls, minimum airflows, and minimum equipment performance standards.

HEATING SYSTEMS

Heating System Control Requirements

1994 LTSGC 3.2

General Requirements

Super Good Cents specifications call for at least one numerically marked thermostat mounted on an interior wall for each separate heating system.

Zonal System Thermostats

Super Good Cents specifications require one heat anticipating or electronically controlled thermostat per zone.

Forced Air Furnace Thermostats

Thermostats for forced air systems must be low voltage, heat anticipating or electronically controlled. Install thermostats according to the manufacturer's instructions.

Heat Pump Thermostats

Thermostats for heat pumps must meet the following requirements:

1. Heat pump thermostats must have a manual changeover feature or a heating/cooling lockout to prevent cross-cycling between heating and cooling modes.
2. If a setback thermostat is selected, it must feature ramped/intelligent recovery to limit use of supplemental heat during recovery periods. The thermostat must have a minimum of two setback periods per day.

3. Heat pump thermostats must have a manual switch capable of energizing emergency heat when the refrigeration cycle is inoperative. The thermostat must feature an indicator light that signals when emergency heat is being used.

Duct System Installation Requirements

A recent study of forced air heating system efficiency indicates an average efficiency loss of 29 percent due to duct system heat loss. Heat produced by the furnace is lost before it arrives in living areas. To reduce duct losses, Super Good Cents program specifications for forced air systems require extensive duct sealing and high levels of duct insulation.

Duct Air Sealing and Attachment

Air sealing forced air systems in Super Good Cents homes goes well beyond standard practice. All supply and return ducts, the air handler, and plenum connections at the air handler must be sealed. Sealants must be applied at all prefabricated joints, at field joints, at corners, and at longitudinal seams. See Figures 7A, 7B, 7C, and 7D.

Recommended sealants include non-toxic mastics, foil tape with 15-mil butyl sealant, or tape meeting the test standards of UL-181. Sealants must be installed according to the manufacturer's instructions.

Check material safety and data sheets to avoid hazardous materials. Ventilation may be poor during sealant application. Before using special tape, read manufacturer's application instructions to see if you will be able to follow them under site conditions. If site conditions are not optimal, the tape may not form a durable seal.

Research indicates that building cavities used as ducts are very leaky. Examples are panned joist cavities and unducted plenums between crawl spaces and attics in two story construction. It is easier to seal a duct and run it through the cavity than it is to make the cavity tight. See Figure 7E.

Mechanical Fasteners

All joints in the air handler and ducts must be mechanically fastened. Flexible ducts may be mechanically fastened with nylon or plastic straps. They must be tightened with the appropriate strap tightening tool (hand tightened straps do not work) or with stainless steel worm drive clamps. Mastic and tape are not mechanical fasteners.

For assembling flex systems, it is recommended that you seal and mechanically fasten the inner liner to the adjacent metal component, pull the outer liner over everything so that no bare metal is exposed, and mechanically secure the outer liner with strapping. See Figure 7F.

Figure 7A
SEALING AT AIR HANDLING

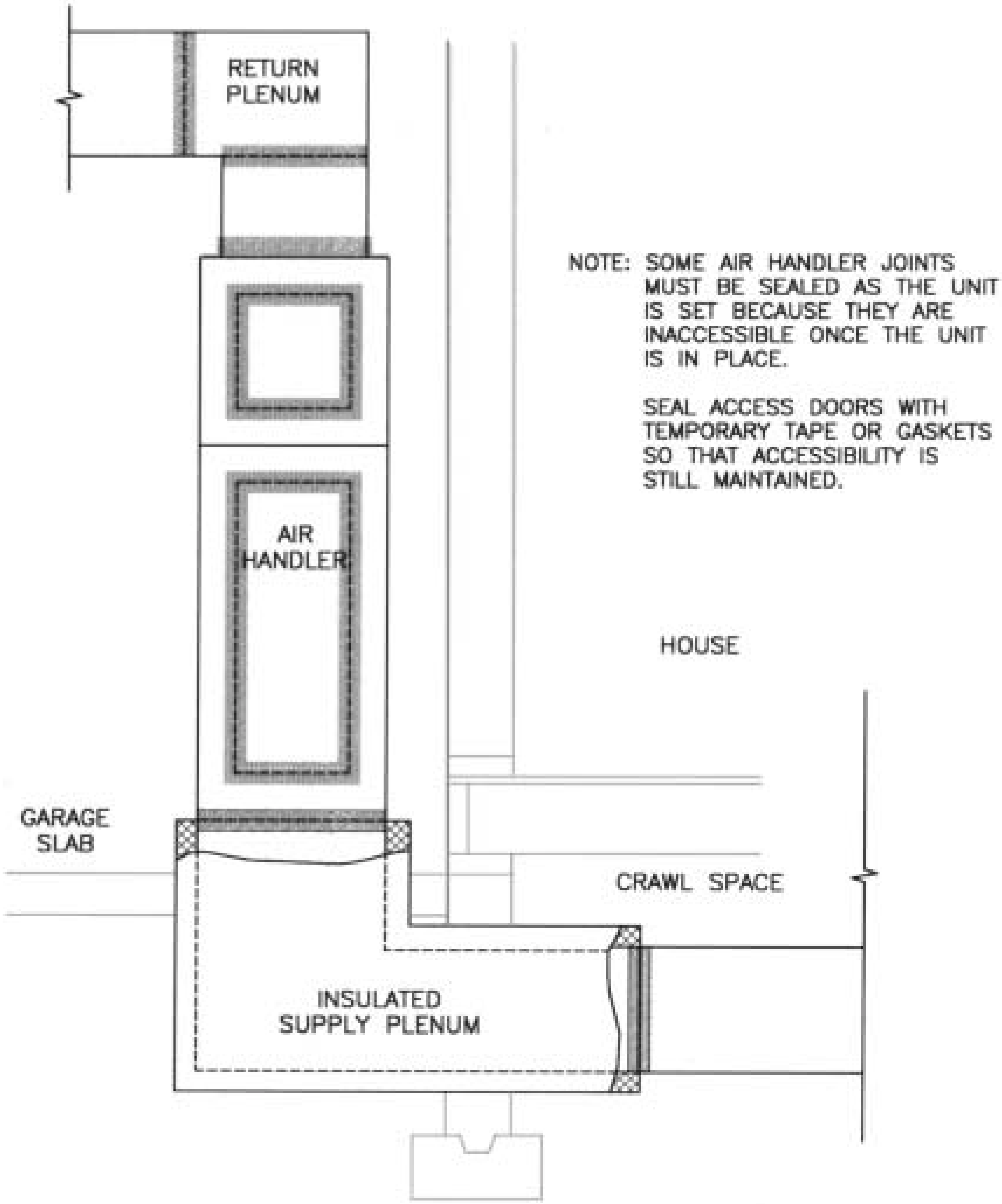


Figure 7B
SEALING AT PELNUM CONNECTIONS

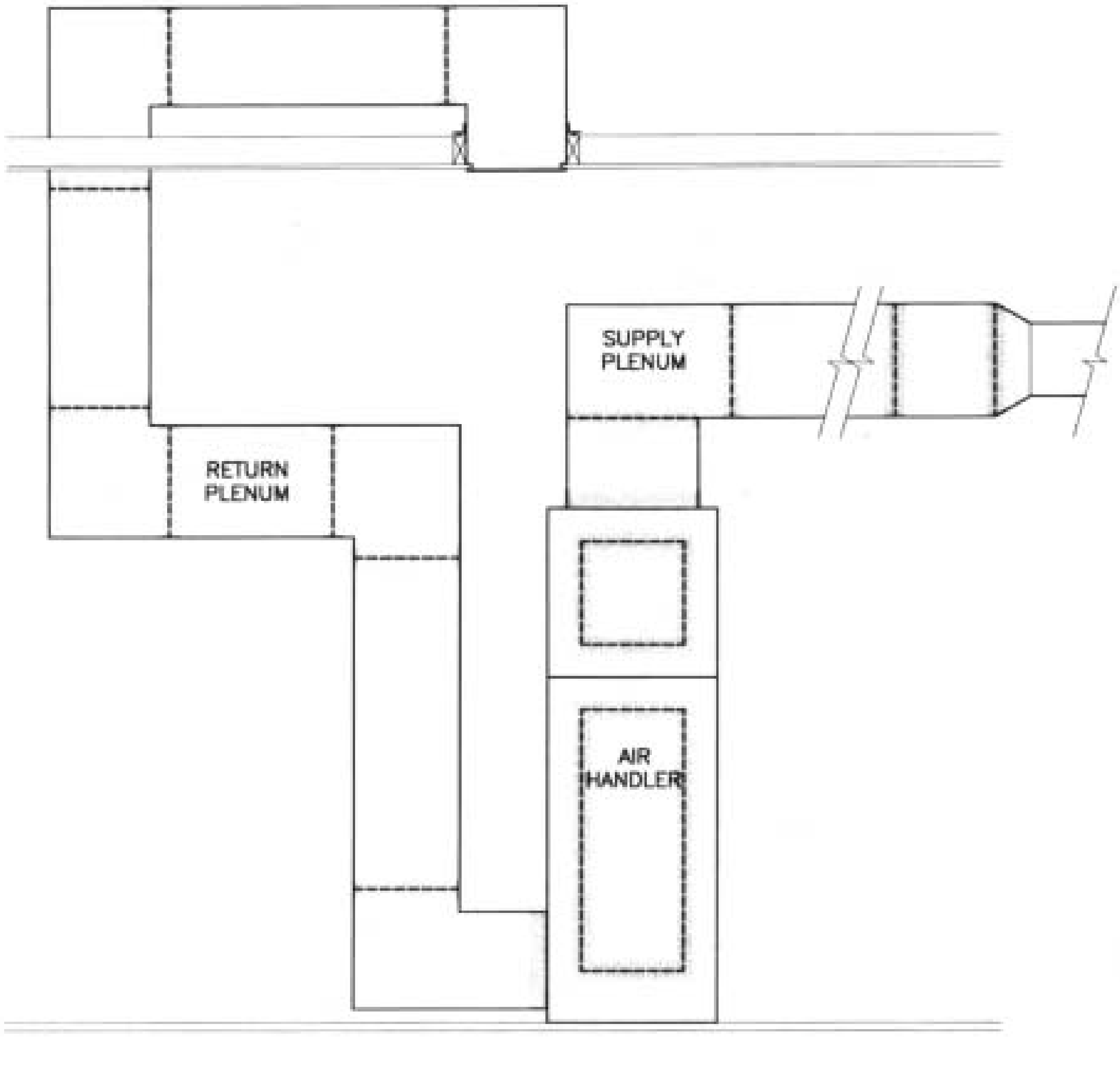


Figure 7C
SEALING AT PLENUM TAKEOFFS

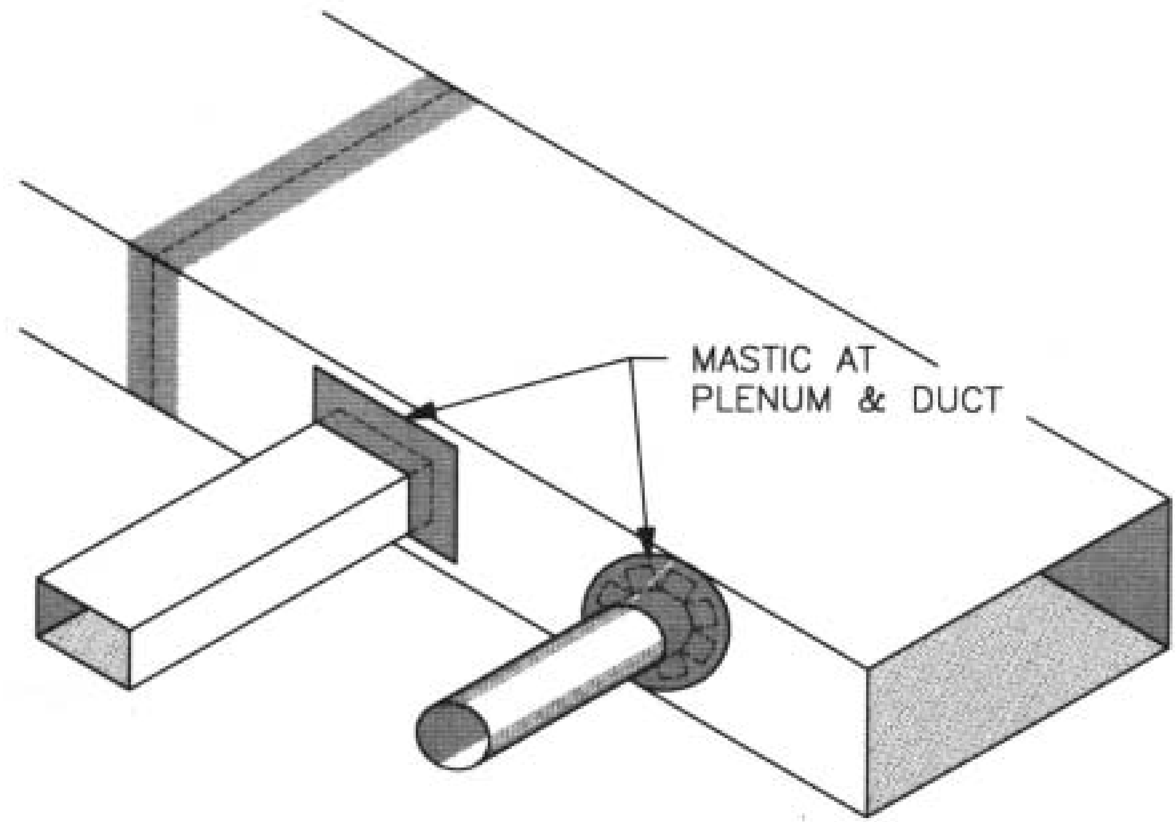


Figure 7D
SEALING AT PREFABRICATED JOINTS AND FIELD JOINTS

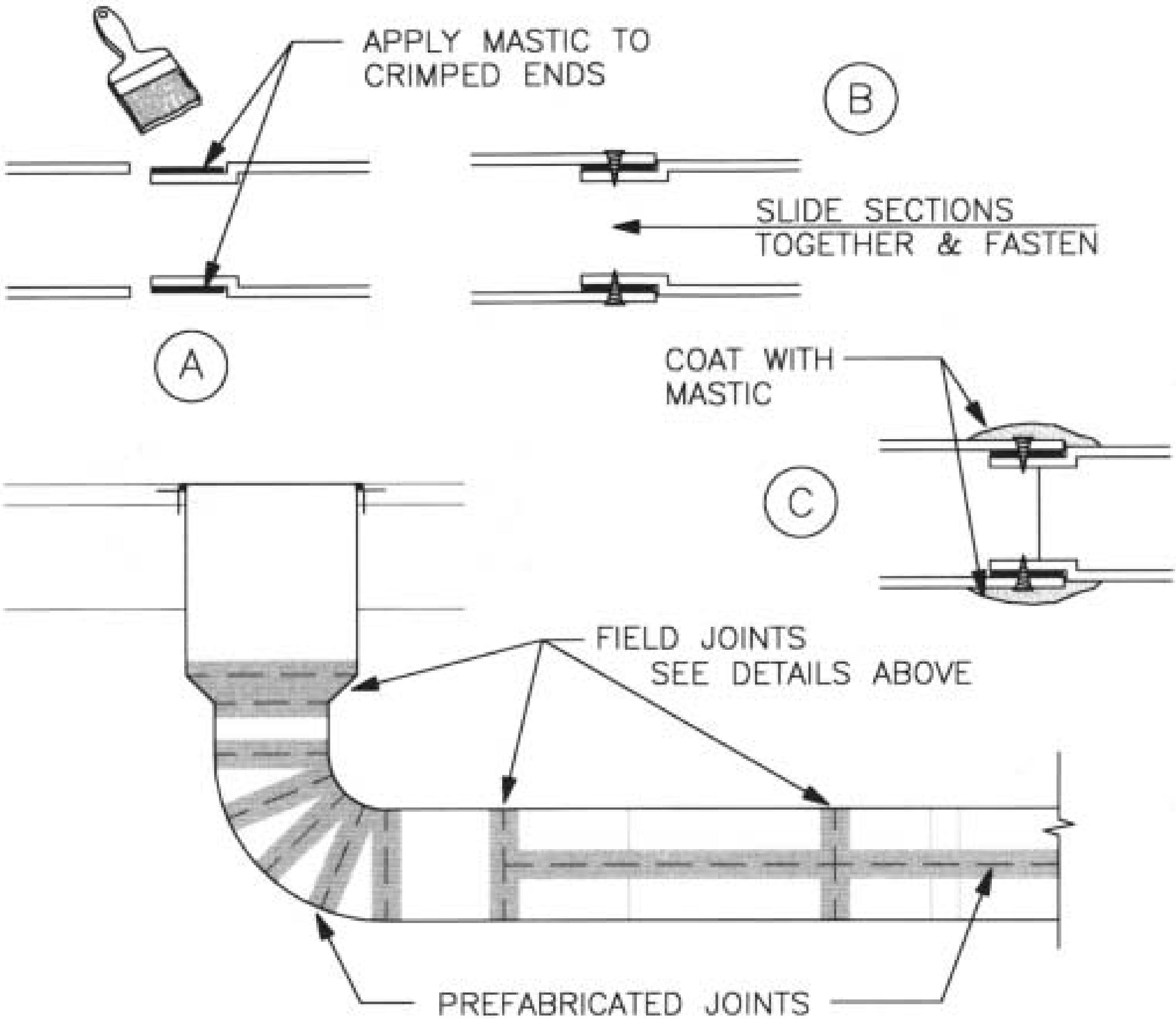
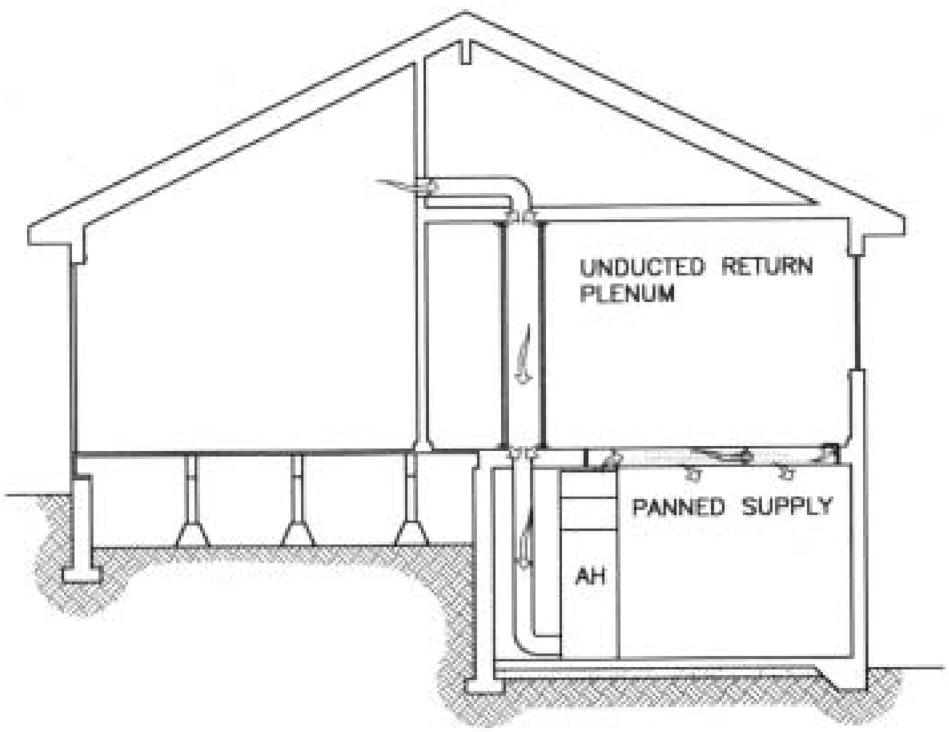


Figure 7F
DUCTED VS. UNDUCTED PLENUMS



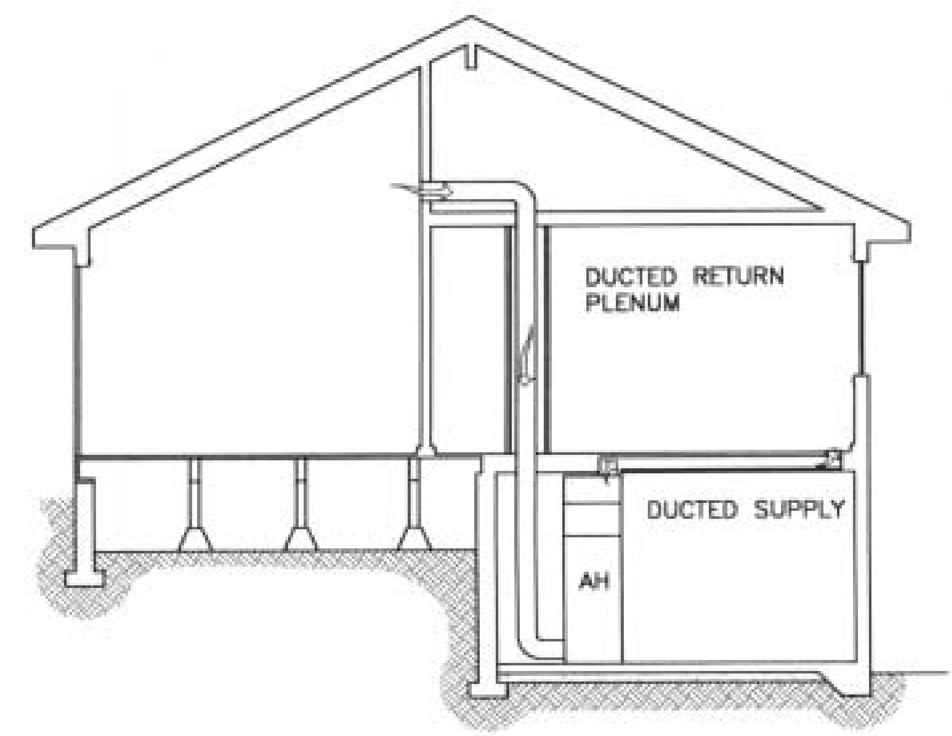
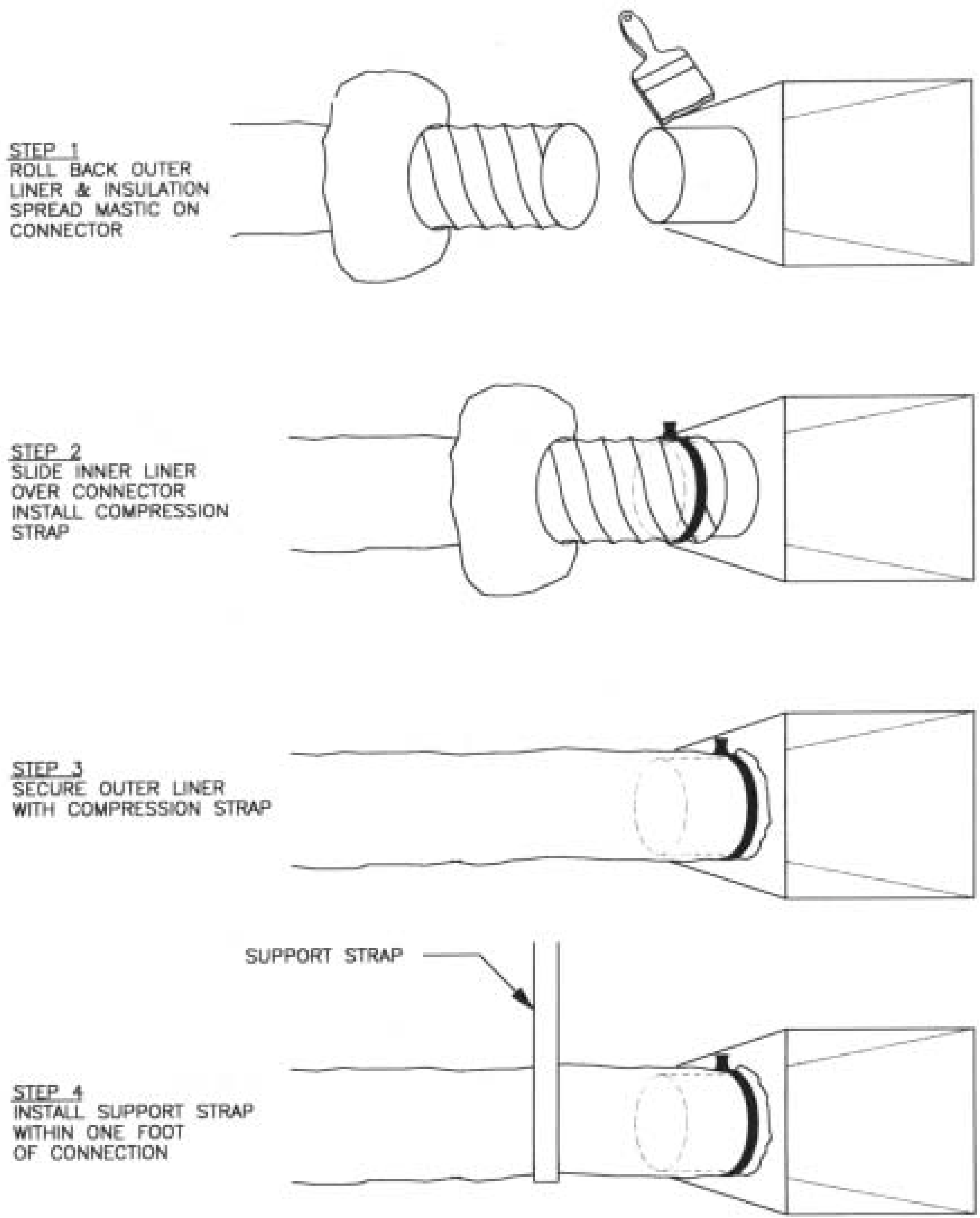


Figure 7F
SEALING AND FASTENING FLEX DUCT



Duct Insulation

Duct insulation is a Super Good Cents qualification measure, just like high efficiency windows and insulation in floors, walls, and ceilings. All components of the duct system should be insulated. See Figure 7G.

Duct insulation must meet the following minimum standards:

Flexible ducts	R-8
Metal ducts	R-11

Duct insulation levels for Super Good Cents homes vary. Higher levels of duct insulation (such as R-19) are sometimes traded for lower levels of insulation in another building component.

The HVAC contractor must install duct insulation levels specified in the Super Good Cents agreement between the builder and utility. Hopefully the builder will inform the HVAC contractor about any special agreements about duct insulation levels.

Qualification problems frequently occur in duct systems that are part metal and part flex. For example, the utility and general contractor may have agreed that the whole system will be insulated to R-11. Not knowing that, the HVAC contractor may install R-8 insulation for flex duct and R-11 insulation for metal duct. Even though these levels meet minimum program standards, the installation does not match the duct insulation level used to qualify the house.

Be sure your bid reflects the cost of the approved duct insulation level. Check with the general contractor or the Super Good Cents utility representative.

One part of the duct system that is frequently overlooked is the section of the supply plenum that runs from the furnace to the crawl space through a hole in the garage slab. See Figure 7H. Super Good Cents utilities are looking for a minimum of R-8 rigid insulation on ducts that are to be enclosed in concrete, but the general contractor may have agreed with the utility to install a higher insulation level. If the plenum is placed before the slab is poured, do not forget the insulation! Or talk to the concrete contractor and specify that the hole in the slab be large enough for the duct plus R-11 insulation. Two-inch foam board is recommended.

R-8 duct board products are acceptable, but are traded with R-11 rigid ducts in the house qualification process. If R-8 duct board is installed, some other component in the house is beefed up to maintain the overall energy performance of the building.

Figure 7G
INSULATED DUCT SYSTEM

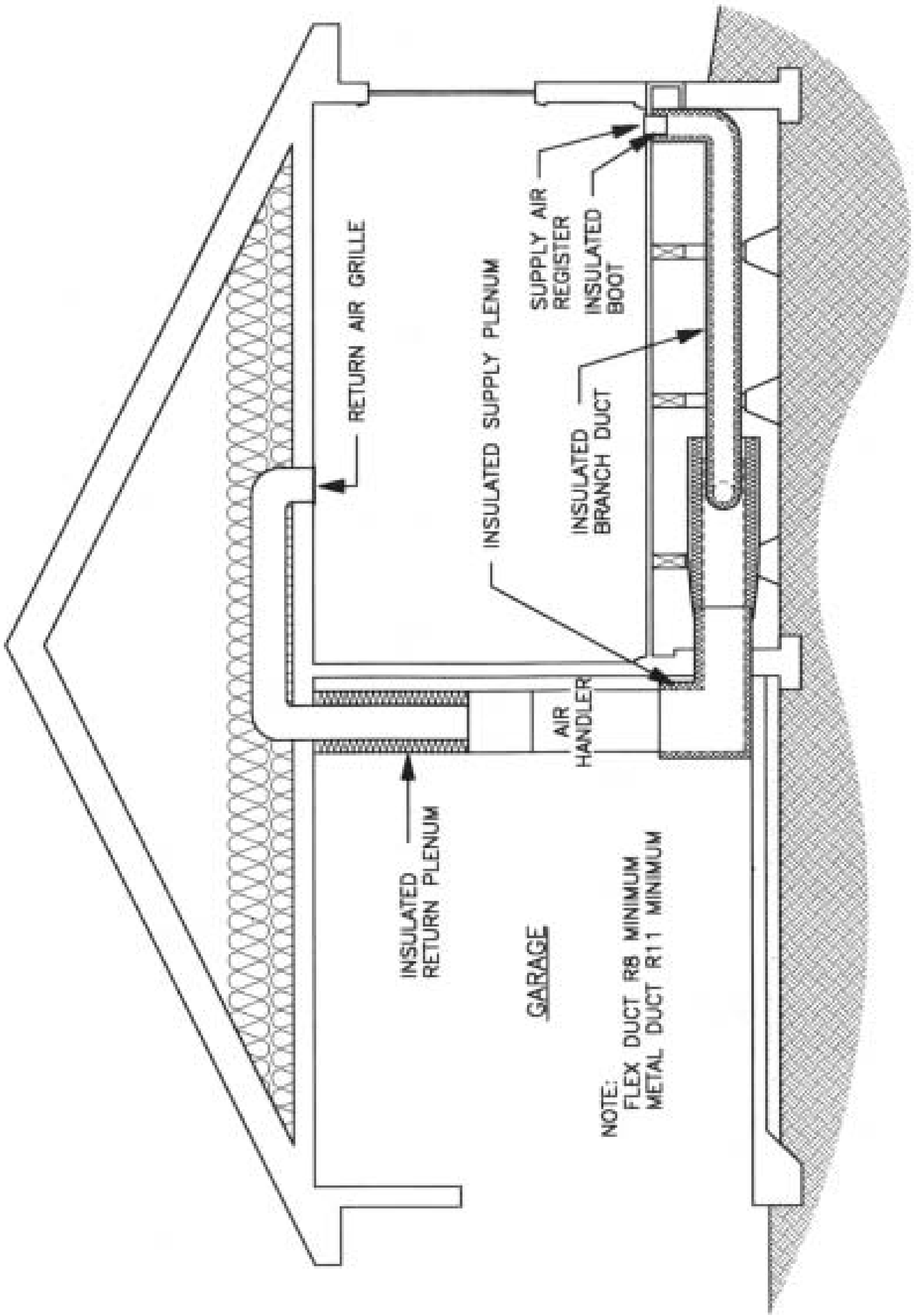
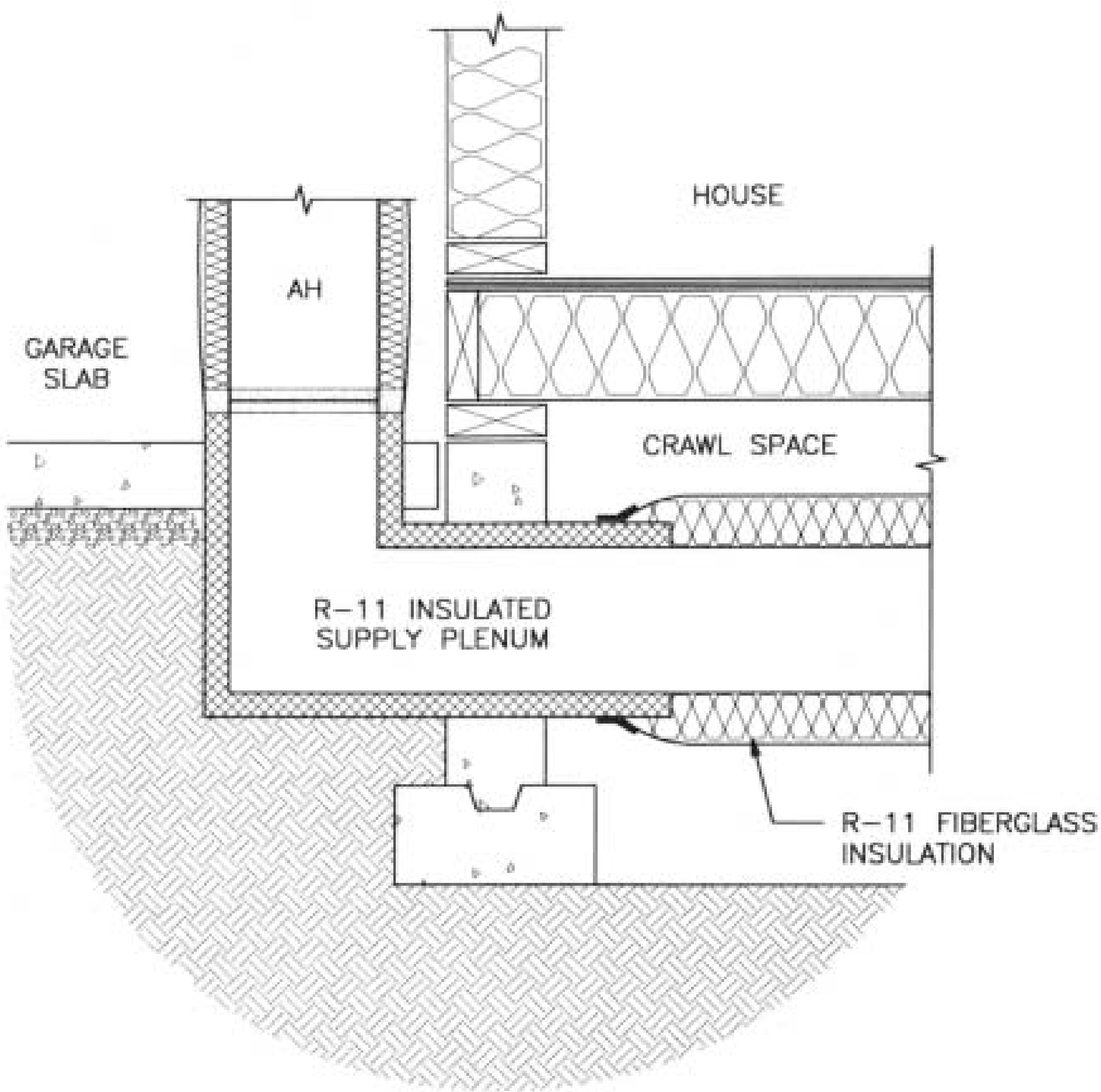


Figure 7H
INSULATED SUPPLY PLENUM IN GARAGE SLAB



Duct Leakage, Duct Design, and Heating System Safety Issues

Recent research demonstrates that forced air system operation can change air pressures inside a home. Air pressure differences created by forced air system operation can have unintended adverse effects on indoor air quality, health and safety, and building durability.

Negative Pressure

Supply leakage to a space outside the building envelope creates negative pressure inside the main living area. See Figure 7I. A home is under negative pressure if air pressure inside is lower than outside. Air will flow into the building (infiltration) through any hole it can find to reestablish neutral conditions. Combustion appliance flues are particularly convenient air paths.

Potential Effects of Negative Pressure on Combustion Appliances

Negative pressure may cause “spillage” of a combustion appliance—temporary venting of combustion gasses into the living space. Spillage is common at startup, before the appliance has a chance to establish a strong draft. Negative pressure prolongs spillage of combustion gasses into the home.

Negative pressure also may pose a fire danger from flame rollout. If negative pressure is strong enough, combustion appliance flames can be pulled out of the combustion chamber at startup and ignite nearby combustibles.

Negative pressure in a combustion appliance zone also may cause “backdrafting,” a complete flow reversal of flue gasses into the living space.

In addition to health and safety effects, supply leakage wastes energy. Heated or cooled air that should be going to the living space is lost to the outdoors. Heat is lost directly through duct leaks, and air pressure changes created by duct leakage induce higher levels of air infiltration through the building envelope.

Positive Pressure

A home is under positive pressure if air pressure inside is higher than outdoors. Air will flow from the home outdoors (exfiltration) any way it can to reestablish neutral conditions.

Concerns about positive pressure focus on where the air is coming from—the source of the air that is pressurizing the home—and potential for pressure driven moisture problems in structural cavities.

In homes with forced air systems, positive pressure in a main living area may indicate leakage in return ducts. See Figure 7J. If a leaky return is in the attic, attic air can be drawn into the house. If return plenums or furnace cabinetry in a garage are leaky, garage air can be drawn into the home.

Under positive pressure conditions, air that flows out of the house carries with it moisture present in indoor air. Moisture can condense in cooler building cavities and cause mold growth, structural decay, siding problems and many other moisture related problems.

Goals of Duct Sealing: Improved Safety, Indoor Air Quality, Building Durability, and Thermal Efficiency

By sealing supply and return ducts carefully as they are installed, the HVAC contractor ensures that heating system operation:

- will have a neutral effect on house air pressures;
- will not create negative or positive air pressure conditions;
- will not draw air from combustion appliance flues, attics, and garages into living spaces;
- will not drive moisture into structural cavities; and
- will avoid energy losses associated with duct leakage.

Central Returns: Door Closure

Many forced air systems are designed so that one or two central return grills serve all supply registers. Central returns often are located in the same zone as a fireplace or wood stove. In homes with forced air systems, central returns, and combustion appliances, closing interior doors can create negative pressure in the return/combustion appliance zone. Air delivered in the zone with the closed door cannot get back to the return, and the return becomes “starved” for air. The return/combustion appliance zone is depressurized (under negative pressure), and the return may pull air from the combustion appliance flue for house makeup air. See Figure 7K.

Combustion appliances are not designed to operate in negative pressure environments. Spillage or backdrafting can result.

To avoid door closure effects in homes with combustion appliances, provide an air path from each supply register back to the return through passive pressure relief grills or distributed returns. See Figures 7L and 7M. Size distributed return grills and ducts using standard duct design procedures. Passive grills probably provide sufficient pressure relief if they provide 1 square inch of net free grill area for each CFM delivered to the room.

Figure 7I
NEGATIVE PRESSURE CREATED BY SUPPLY DUCT LEAKAGE

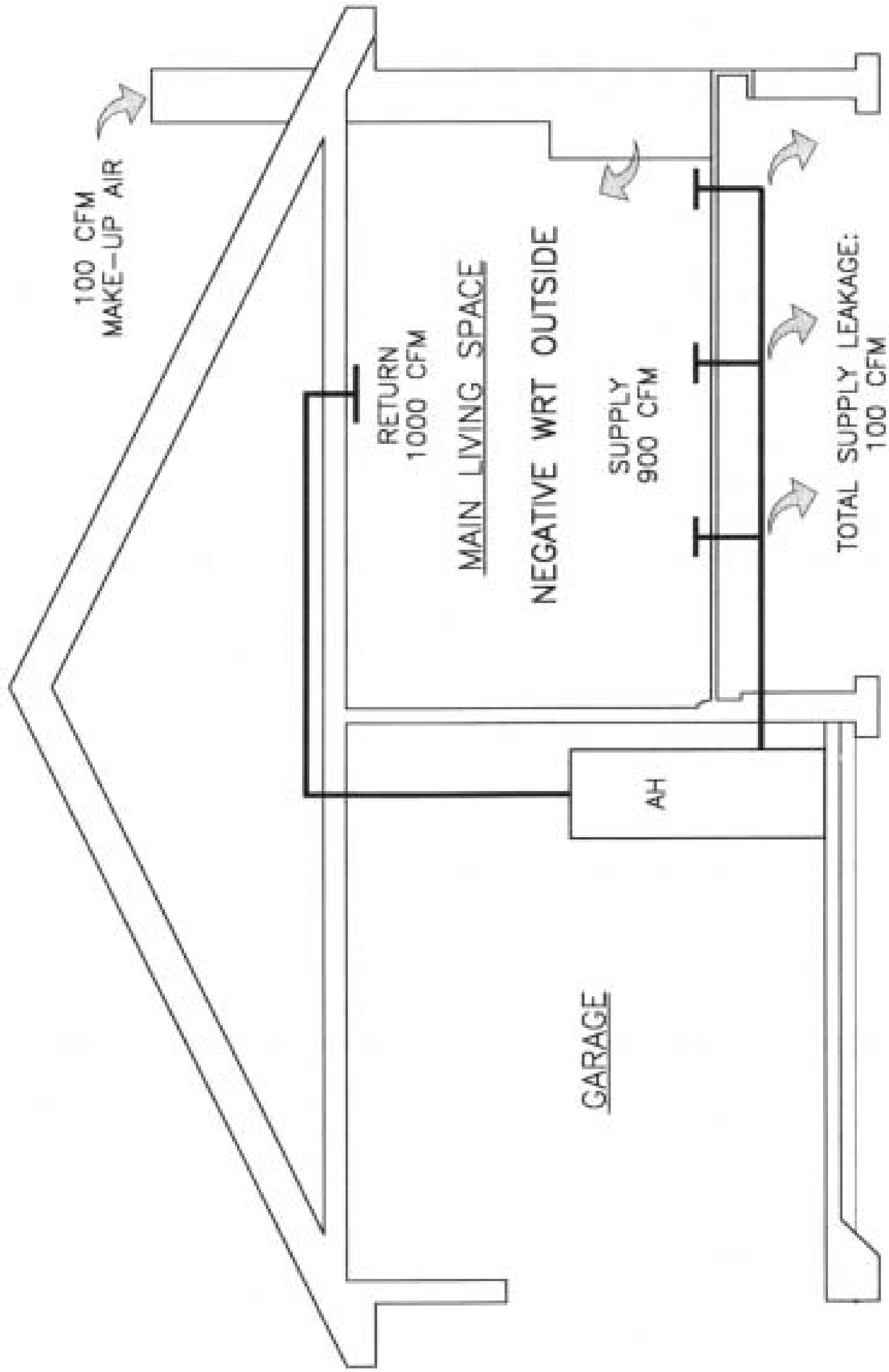


Figure 7J
POSITIVE PRESSURE CREATED BY SUPPLY DUCT LEAKAGE

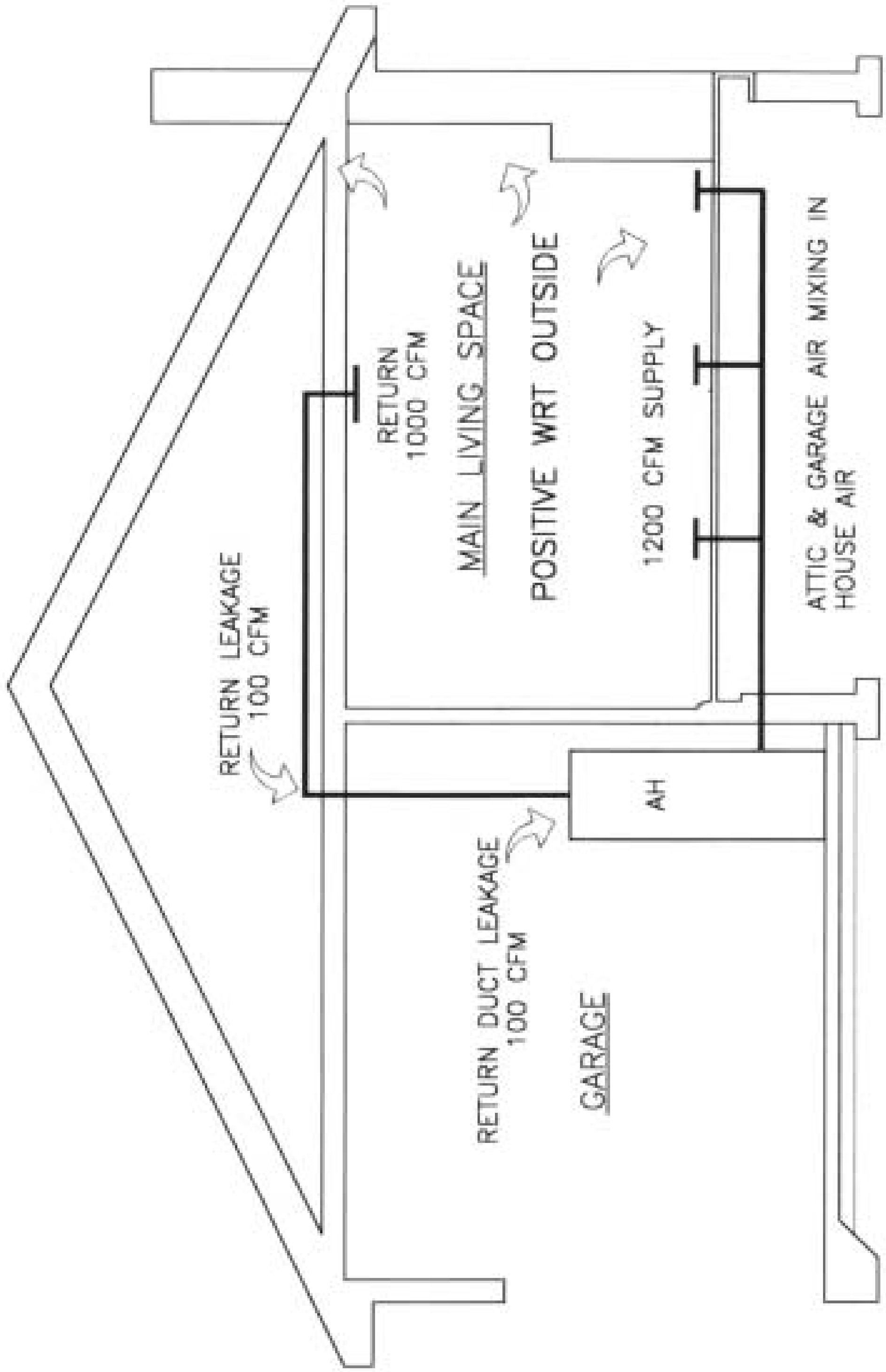


Figure 7K
DOOR CLOSURE EFFECT

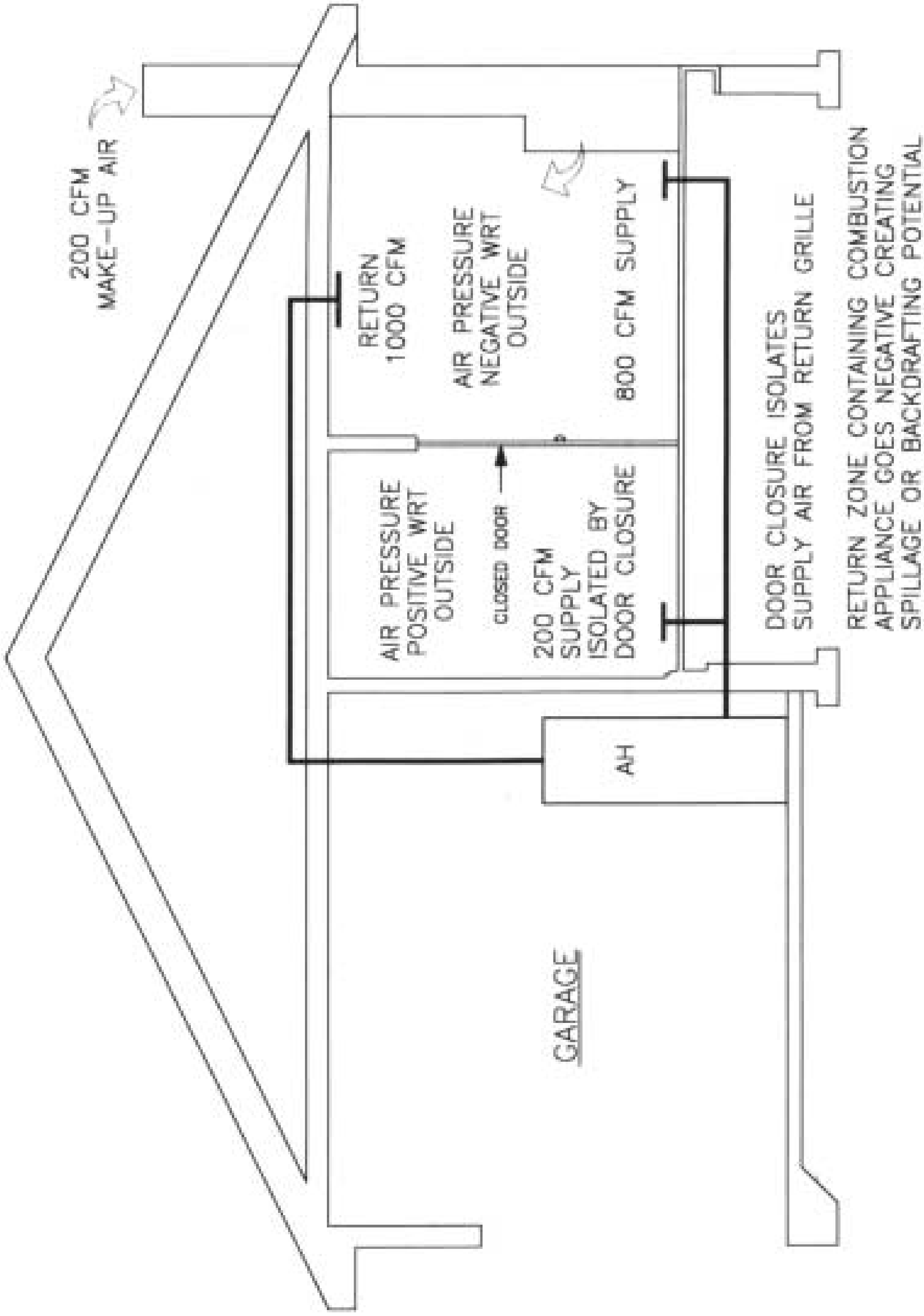
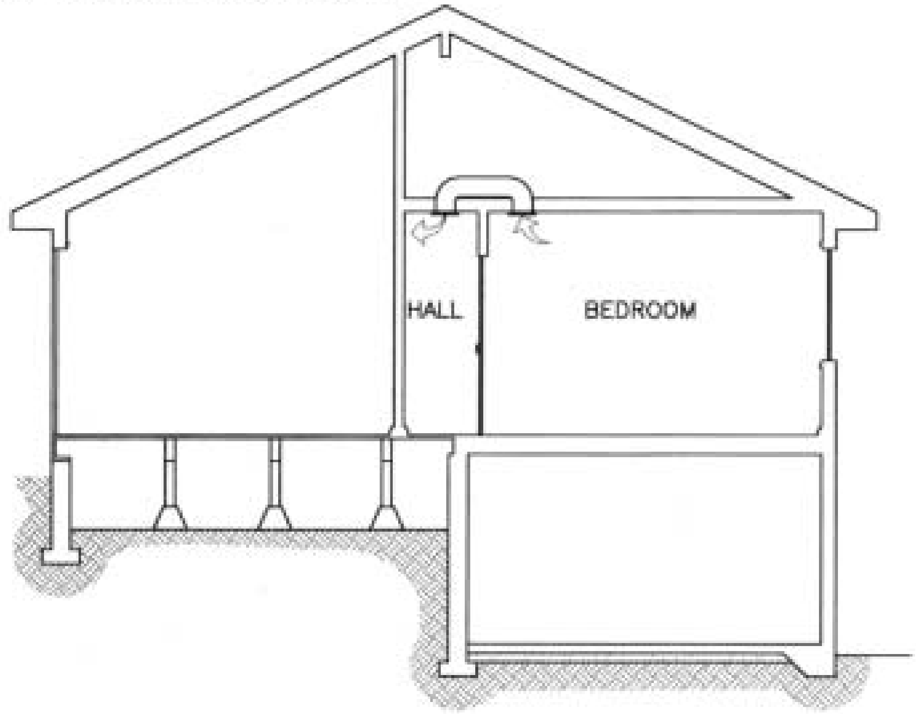


Figure 7L
PASSIVE PRESSURE RELIEF

DUCT THROUGH CEILINGS INTO HALL



THROUGH–WALL TRANSFER GRILLE
TO HALLWAY

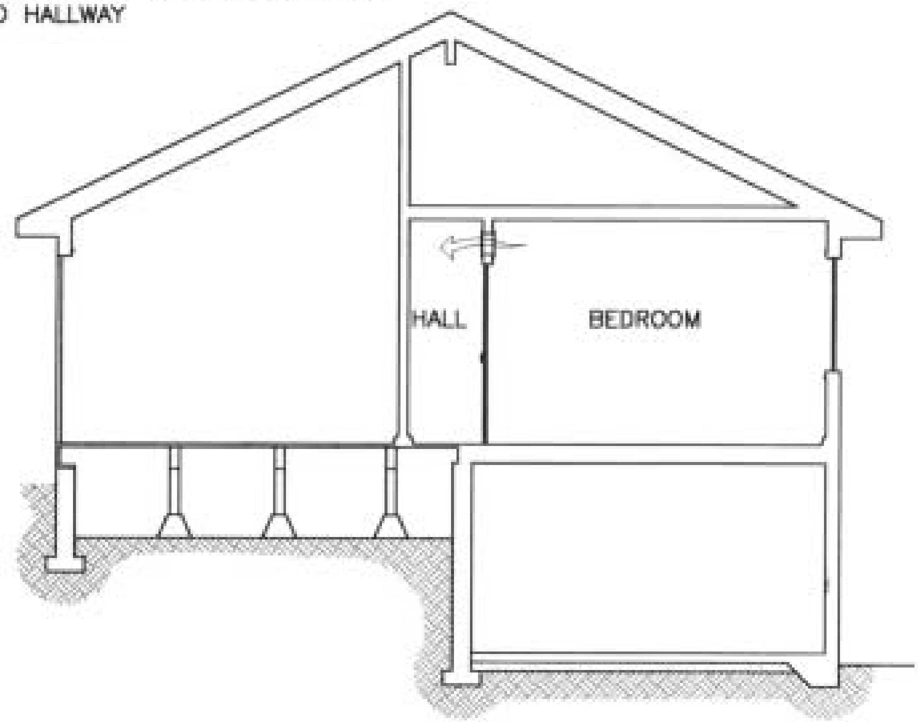
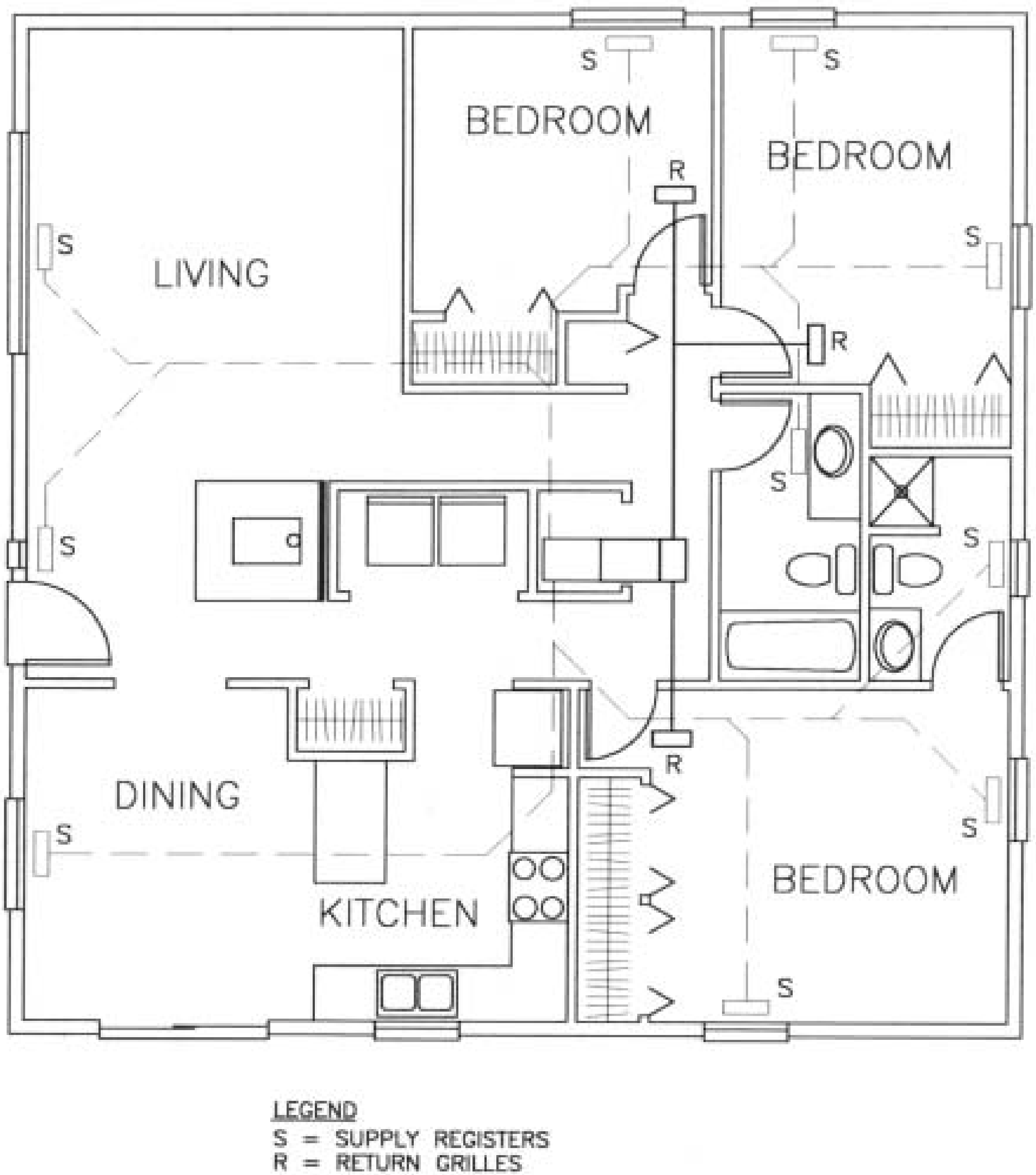


Figure 7M
DISTRIBUTED RETURN



VENTILATION SYSTEMS INSTALLED BY THE HVAC CONTRACTOR

1994 LTSGC 4.3

Ventilation Approaches for Multifamily Units (Six or more units)

Any of the following whole house ventilation systems are approved for use in multifamily housing: 1) Multifamily Continuous Ventilation; 2) Multifamily Intermittent Ventilation; and 3) Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System.

Multifamily Continuous Ventilation and Multifamily Intermittent Ventilation are usually installed by the electrical contractor. Chapter 5 of this guide describes these systems. Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System usually is installed by the HVAC contractor and is described below.

Table 7.1 shows minimum (and maximum) fan CFM ratings for continuous ventilation systems in multifamily buildings. The flow rates also are the basis for required intermittent flow rates when ventilation is provided by the forced air system. Table 7.1 CFM minimums apply when only the whole house fan provides whole house ventilation and separate spot ventilators serve the kitchen and baths.

Table 7.1
CONTINUOUS VENTILATION RATES FOR MULTIFAMILY CONSTRUCTION - WHEN SPOT FANS ARE SEPARATE

LTSGC 4.3, Table A

Number of Bedrooms	Min. Certified Fan Flow @ 0.25" w.g.	Max. Certified Fan Flow 0.25" w.g.
1	30 CFM	60 CFM
2	50 CFM	75 CFM
3	60 CFM	90 CFM
4	80 CFM	120 CFM

INTERMITTENT VENTILATION RATES FOR MULTIFAMILY CONSTRUCTION

Intermittent ventilation rates for multifamily construction require CFM ratings 1.5 times the minimum prescriptive flows specified in Table 7.1.

Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System

The ventilation system may be integrated with the heating/cooling system only if each multifamily unit has a separate forced air system. The HVAC contractor usually takes the lead in installing these systems, but may have the electrical contractor provide a 24-hour timer, an exhaust fan, and a 24-volt control circuit for the furnace fan and motorized damper. The HVAC contractor may provide the final furnace and damper hookups.

A whole house exhaust fan must be installed that meets multifamily CFM requirements (for intermittent systems), is controlled by a 24-hour timer with a manual override switch, and is set to provide a minimum ventilation period of 8 hours per day. The 24-hour timer also controls the furnace fan and a motorized damper on a duct that delivers fresh air to the furnace return plenum. When the timer calls for ventilation, the exhaust fan comes on, the motorized damper opens, and the furnace fan comes on. Stale air is exhausted from the residence and fresh air is distributed throughout the home. See Figures 7N-1, 7N-2, and 7N-3.

To avoid creating negative pressure environments in multifamily units with combustion appliances, the amount of air coming in through the furnace must match the amount of air exhausted by the whole house fan. You may need to call the electrical contractor, general contractor, or Super Good Cents representative to determine the correct ventilation CFM and, therefore, the correct amount of fresh air to bring in through the heating system, and how to provide it.

Table 7.2
AIR INLET DUCT LENGTH VS. DIAMETER

LTSGC 4.3.7.1, Table E

Number of Bedrooms	Min. Smooth Duct	Min. Flex Duct Diameter	Max. Duct Length[1]	Max. Number of Elbows[2]
2 or less	6"	7"	20 ft	3
3	7"	8"	20 ft	3
4 or more	8"	9"	20 ft	3

Notes:
[1] For lengths over 20 ft, increase duct diameter by 1 inch.
[2] For more than three elbows, increase duct diameter by 1 inch.

Figure 7N-1

WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING

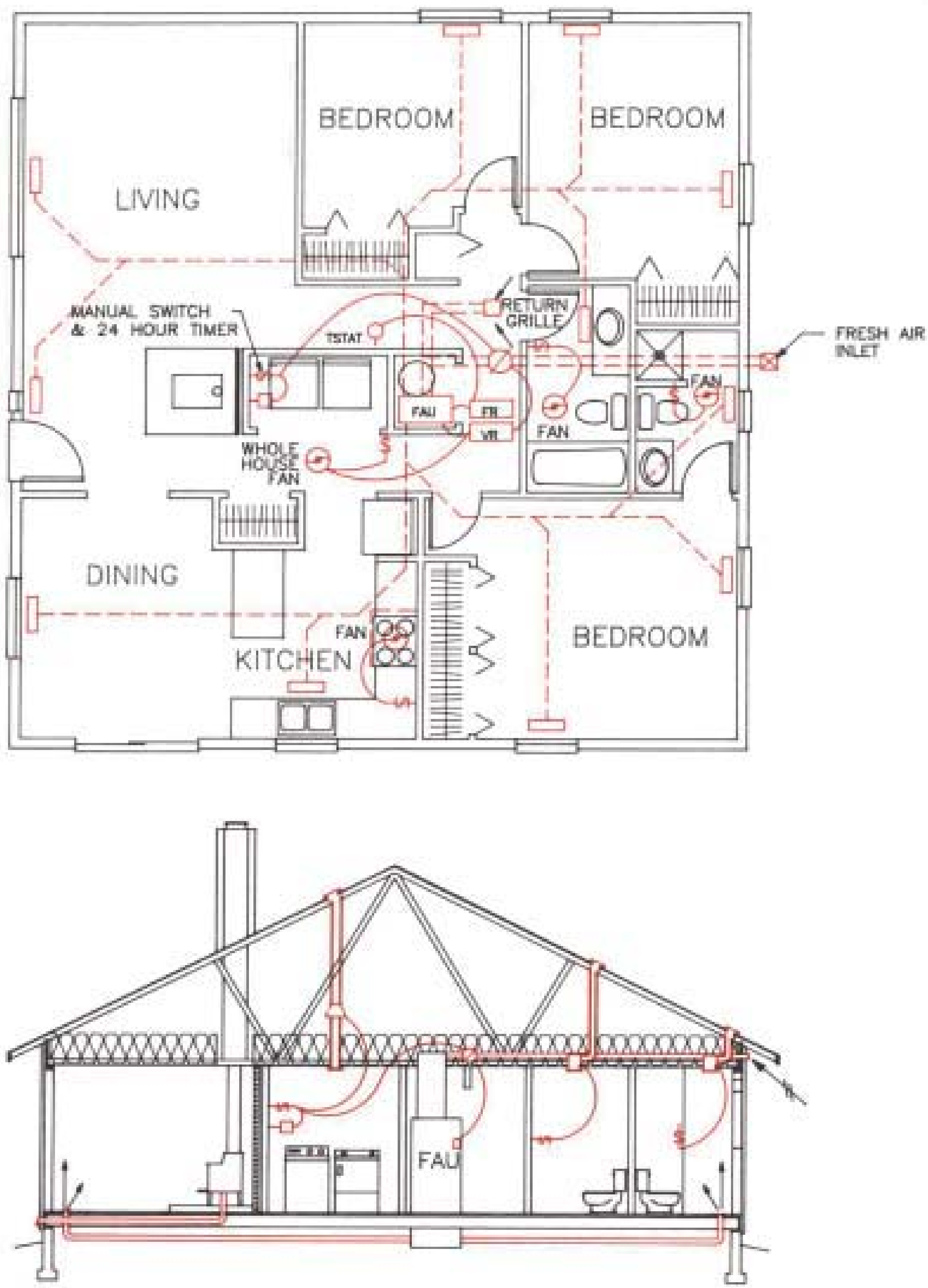


Figure 7N-2
EXAMPLE 1 CONTROL WIRING SCHEMATIC:
WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING

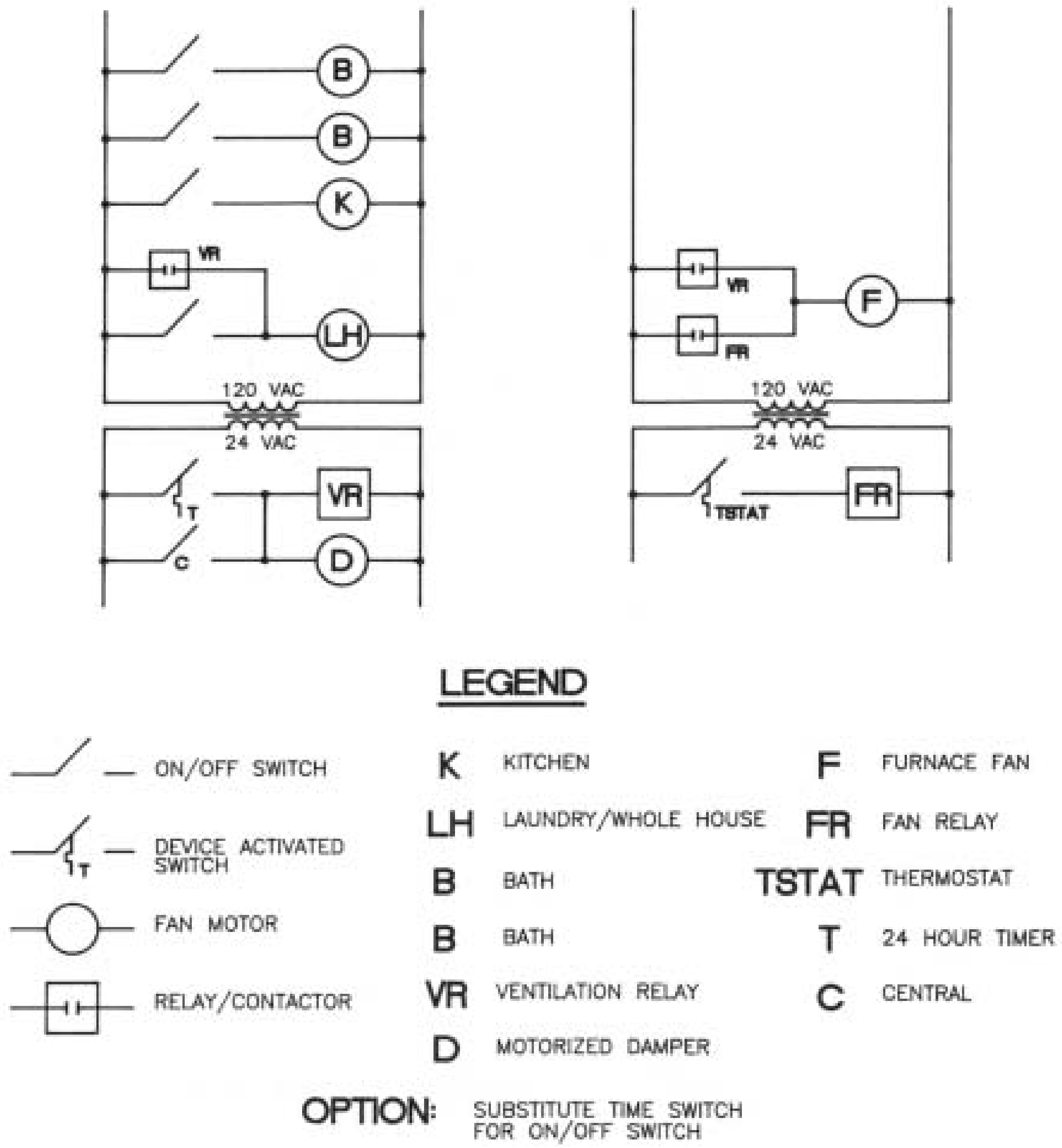
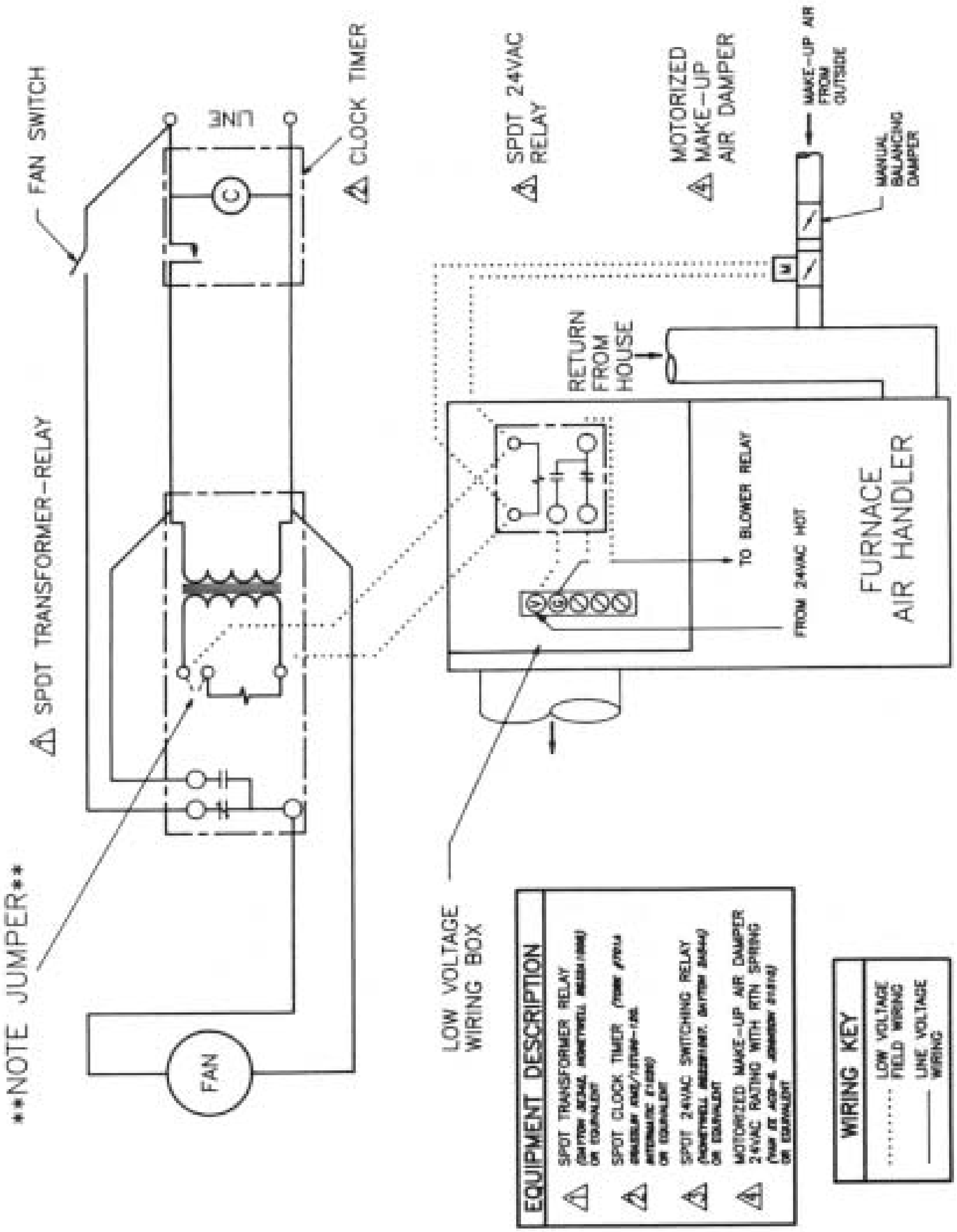


Figure 7N-3
EXAMPLE 2 CONTROL WIRING SCHEMATIC:
WHOLE HOUSE VENTILATOIN INTEGRATED WITH FORCED AIR HEATING/COOLING



Install the pickup point for the fresh air intake duct in a location where it will not pick up pollutants or odors. Places to avoid are close to grade level, areas where cars park, and roofs where asphalt or other petroleum products are used. Protect the pickup from rain, insects, leaves, and other objects. Keep the duct length as short and straight as practical.

Dampers

Unless the ventilation system is continuous, the intake duct must have a mechanical damper that opens only when ventilation is called for. The intake duct also must have a fixed damper or other air volume control set to provide the required airflow through the duct.

Simple pressure tests can determine whether the system is balanced as intended. Contact your Super Good Cents utility or state technical assistance provider.

Whole House Ventilation Approaches for Single Family Construction (Five units or less)

Four different approaches are approved for whole house ventilation in single family construction: 1) Single Family Integrated Spot and Whole House Ventilation, 2) Single Family Continuous Ventilation, 3) Single Family Discrete Spot and Whole House Ventilation, and 4) Single Family Intermittent Ventilation Integrated With Ducted Forced Air System.

Single Family Integrated Spot and Whole House Ventilation, Single Family Continuous Ventilation, and Single Family Discrete Spot and Whole House Ventilation usually are installed by the electrical contractor. Chapter 5 describes these systems. Single Family Intermittent Ventilation Integrated With Ducted Forced Air System usually is installed by the HVAC contractor and is described below.

Ventilation Rates for Single Family Construction

Table 7.3 specifies minimum flow rates for intermittent systems. Minimum flow for continuous systems is 20 CFM per bathroom plus 25 CFM for the kitchen.

Table 7.3
SINGLE FAMILY INTERMITTENT VENTILATION

LTSGC 4.3.1, Table B

Number of Bedrooms	Min. Certified Fan Flow @ 0.25" w.g.	Max. Certified Fan Flow @ 0.25" w.g.
2 or less	50 CFM	75 CFM
3	80 CFM	120 CFM
4	100 CFM	150 CFM
5	120 CFM	180 CFM

Single Family Intermittent Ventilation Integrated With Ducted Forced Air System

The ventilation system may be integrated with the heating/cooling system if the home has a forced air system. The HVAC contractor usually takes the lead in installing these systems, but may have the electrical contractor provide a 24-hour timer, the whole house exhaust fan, and a 24-volt control circuit for the furnace fan and motorized damper. The HVAC contractor may provide the final furnace and damper hookups.

A whole house exhaust fan must be installed that meets CFM requirements (for intermittent systems), is controlled by a 24-hour timer with a manual override switch, and is set to provide a minimum ventilation period of 8 hours per day. The 24-hour timer also controls the furnace fan and a motorized damper on a duct that delivers fresh air to the furnace return plenum. When the timer calls for ventilation, the exhaust fan comes on, the motorized damper opens, and the furnace fan comes on. Stale air is exhausted from the residence and fresh air is distributed throughout the home. See Figures 7N-1, 7N-2, and 7N-3.

To avoid creating negative pressure environments in single family homes with combustion appliances, the amount of air that comes in through the furnace must match the amount of air that is exhausted by the whole house fan. You may need to call the electrical contractor, general contractor, or Super Good Cents representative to determine the correct ventilation CFM and, therefore, the correct amount of air to bring in through the heating system.

Table 7.4
AIR INLET DUCT LENGTH VS. DIAMETER

LTSGC 4.3.7.1, Table E

Number of Bedrooms	Min. Smooth Duct	Min. Flex Duct Diameter	Max. Duct Length[1]	Max. Number of Elbows[2]
2 or less	6"	7"	20 ft	3
3	7"	8"	20 ft	3
4 or more	8"	9"	20 ft	3

Notes:
[1] For lengths over 20 ft, increase duct diameter by 1 inch.
[2] For more than three elbows, increase duct diameter by 1 inch.

Install the pickup point for the fresh air intake duct in a location where it will not pick up pollutants or odors. Places to avoid are close to grade level, areas where cars park, and roofs where asphalt or other petroleum products are used. Protect the pickup from rain, insects, leaves, and other objects. Keep the duct length as short end straight as practical.

Dampers

Unless the ventilation system is continuous, the intake duct must have a mechanical damper that opens only when ventilation is called for. The intake duct also must have a fixed damper or other air volume control set to provide the required airflow through the duct.

Simple pressure tests can determine whether the system is balanced as intended. Contact your Super Good Cents utility or state technical assistance provider.

Heat Recovery Ventilation Systems

The HVAC contractor may be responsible for installing a central heat recovery ventilation system.

Air-to-Air Heat Exchangers

Air-to-air heat exchangers (AAHXs) are central ducted ventilation systems that bring fresh air into a building and pull stale air out. Airflows to and from the building are routed through a heat exchanger core that transfers heat from the outgoing stale air to incoming fresh air. Because the systems are balanced, they are a good choice for ventilation in homes with combustion devices. Balanced systems do not create negative pressure environments, avoiding potentially unsafe interactions with combustion appliances.

AAHXs are not designed to handle range hood exhaust. Kitchen spot ventilation can be achieved through the AAHX by providing a recirculating hood over the stove and a separate exhaust pickup at the kitchen ceiling. Provide an 8-ft horizontal separation between the range top and the kitchen exhaust pickup location.

Minimum AAHX airflow rates and equipment performance standards. Super Good Cents specifications require minimum airflows as described above in Tables 7.1 and 7.3. Do not over ventilate.

If the air-to-air heat exchanger is being installed as a Super Good Cents program option, it must meet certain minimum performance standards. In homes larger than 1,300 square feet, equipment must have a sensible heat recovery efficiency of 65 percent at 117 CFM and 32°F. For houses smaller than 1,300 square feet, the unit must have a sensible heat recovery efficiency of 55 percent at 64 CFM and 32°F, as certified by the Home Ventilating Institute. Include manufacturer's product information with the plans. That way the plan reviewer can verify that the equipment provides required minimum flows and meets performance specifications.

AAHX installation. Locate the AAHX where it is readily accessible for changing air filters and any other maintenance required by the manufacturer. Locating the unit indoors improves heat recovery efficiency. Indoor locations also make access for maintenance easier.

Make the general contractor or electrical contractor aware that a dedicated circuit is recommended.

Since most AAHXs generate condensate, you will probably need to have the plumbing contractor provide a connection to a drain.

AAHXs work most efficiently when exhaust and supply airflows are balanced. This requires a warm side balancing damper in both the main supply and exhaust ducts. Flow hoods or flow grids can be used to verify balanced flow.

Install adjustable grills or registers on each fresh air delivery and exhaust air pickup point. They allow airflow adjustment in each room. Measuring is the only way to ensure that the system is balanced and delivering the design airflow to each space.

AAHX design assistance. Correct design of duct systems and selection of the right terminal devices are critical to successful installations. Many manufacturers have excellent design and installation manuals. Following are other sources of help with AAHX ventilation system design:

Installer's Manual of Heat Recovery Ventilators, available from Home Ventilating Institute, 30 West University Drive, Arlington Heights, IL 60004; 708-394-0150.

"Air-to-Air Heat Exchanger Systems: Marketing, Design and Installation" - Video training tape and study guide available from Super Good Cents utilities or Oregon State University Extension Energy Program, Batcheller Hall 344, Corvallis, OR 97331-2405, 503-737-3004.

Figures 7O-1 and 7O-2 show a typical ventilation system design using an AAHX.

Exhaust Air Heat Pumps

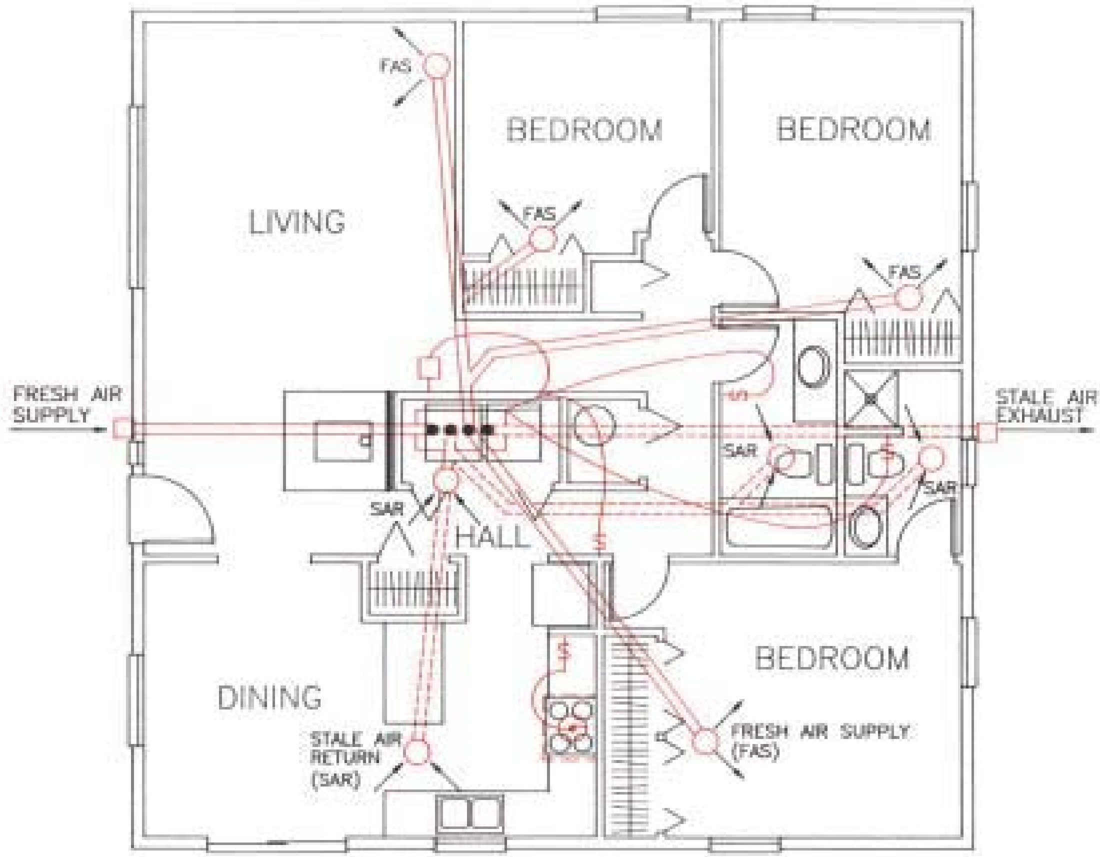
Exhaust air heat pumps (EAHPs)—sometimes called "ventilating heat pump water heaters"—are exhaust ventilation systems that use a small heat pump to recover heat from outgoing stale air. The heat is pumped into the home's hot water system. HVAC contractors typically install them because the system involves refrigeration equipment and oftentimes ducts. The heat recovery efficiency of an EAHP is better than an air-to-air heat exchanger, but the ventilation it provides is not balanced unless you provide makeup air equivalent to exhaust flow. Figure 7P-1 shows layout of a typical EAHP system.

EAHPs: Water heating only. Most EAHPs heat water only. Exhaust air flows over an evaporation coil on top of the water heater tank (usually supplied with the EAHP). Exhaust air can be ducted from a central location in the house (most economical installation) or from bathrooms, utility rooms, and even kitchens.

Ducting from bathrooms is more expensive, but it is a good way to provide high quality spot ventilation. If you use an EAHP to ventilate kitchens, make sure stale air is not picked up right above the stove top. That could cause problems with grease accumulation. Instead, use a range hood to pick up stale air from the range. Use the EAHP pickup for general kitchen stale air and moisture.

EAHPs: Space conditioning option. Some EAHPs offer an option to provide supplemental space heating and cooling. This increases their heat recovery efficiency. The systems require additional ductwork to and from the space(s) being cooled or heated and a heating/cooling thermostat in each space. Generally, they provide space conditioning at about 7,000 Btu/hr. That is adequate for supplemental conditioning of a fairly large zone in the house, such as a family room, living room, or great room.

Figure 7O-1
AIR-TO-AIR HEAT EXCHANGER VENTILATION SYSTEM



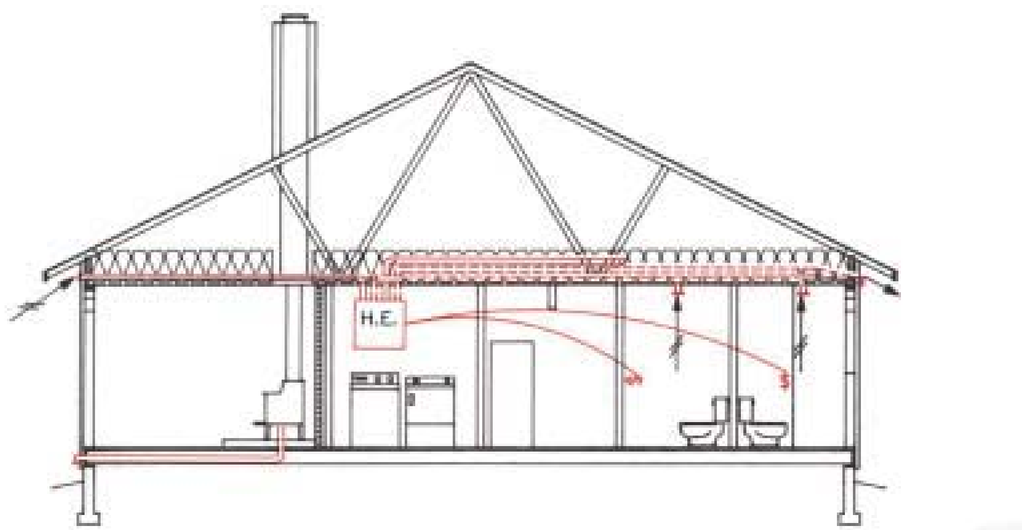
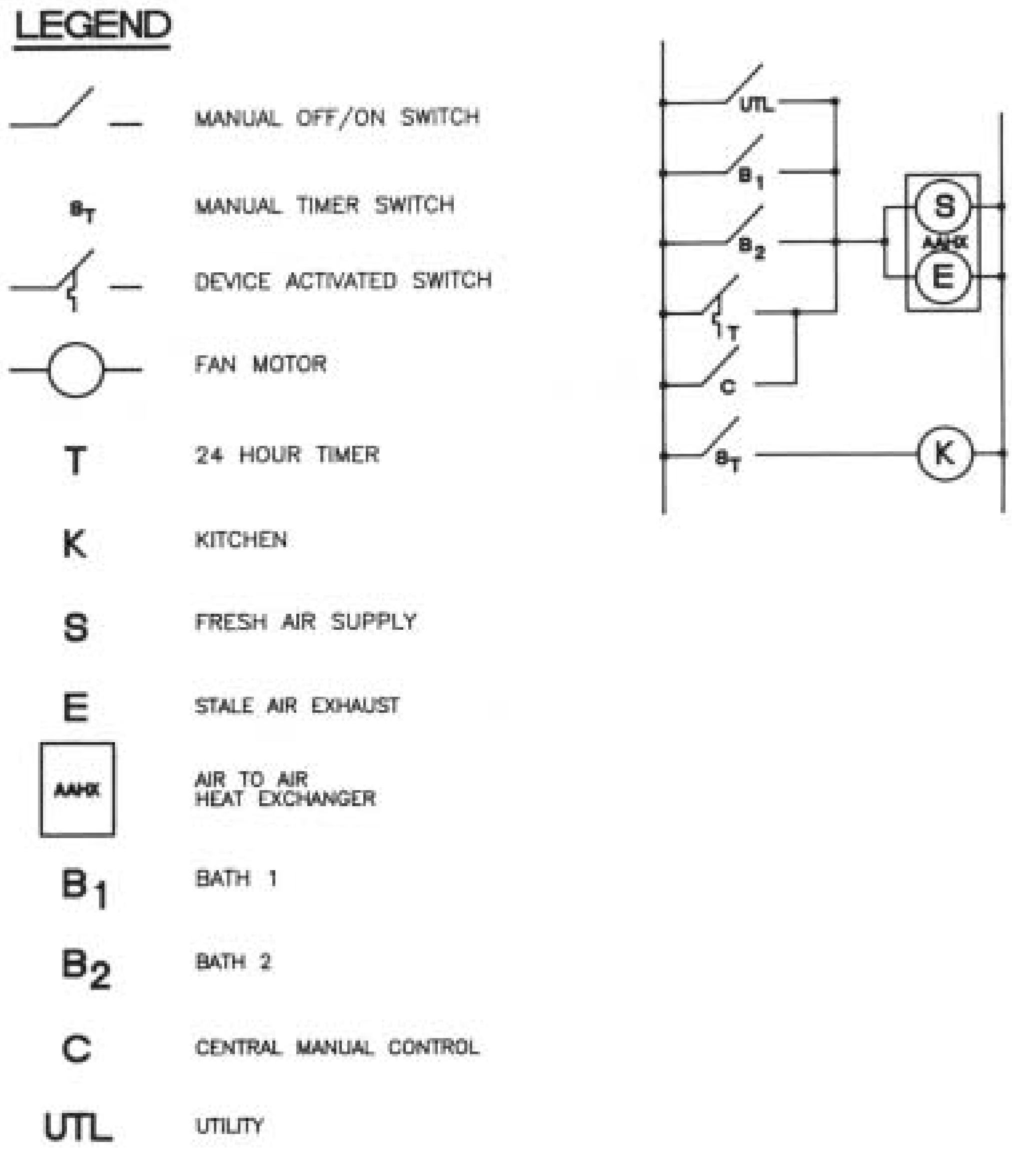


Figure 7O-2
CONTROL WIRING SCHEMATIC:
AIR-TO-AIR HEAT EXCHANGER VENTILATION SYSTEM



EAHP installation. EAHPs can be installed most places you would install a regular water heater. It is a good idea to locate the unit where duct runs can be kept inside the heated space as much as possible, and where duct runs can be kept short and simple. Installation in a utility room often works well.

One difference from installing a conventional water heater is that the plumber must install a condensate drain line to a vented drain. It disposes of water condensed out of the cooled exhaust air.

Requirements for wiring, refrigerant lines, and supply water locations vary from unit to unit. Make sure you have the manufacturer's instructions and templates in hand when you make the bid.

Sizing EAHP airffows. The exhaust air minimum flows for EAHPs are the same as for any Super Good Cents ventilation system. See Tables 7.1 and 7.3 for requirements.

EAHP controls. EAHPs have two main controls:

One controls hot water use. When water is drawn from the tank, the tank thermostat calls for heat and turns on the exhaust fan. The heat pump moves heat into the tank. This is effective control since hot water use usually indicates someone is in the house and ventilation is needed.

The second control is a 24-hour clock timer. It is set to turn on the ventilation system at preset times during the day. Super Good Cents specifications require that the timer be set to provide ventilation at least twice a day, for a minimum total ON time of 8 hours. Ventilation is more effective when ON intervals are distributed throughout occupied daylight hours and during sleeping periods. Timing some of the daily ventilation intervals to precede hot water use periods is a good idea.

Figures 7P-2, 7P-3, 7P-4, and 7P-5 show typical operating sequences for EAHPs.

EAHP fresh air supply. The EAHP provides only exhaust and control elements of a ventilation system. Framers or finish carpenters need to be sure there is a fresh air supply. Most common are fresh air inlets in bedrooms and other locations in the house. Chapter 2 has more information on fresh air inlets.

Figure 7P-1
EXHAUST AIR HEAT PUMP VENTILATION SYSTEM

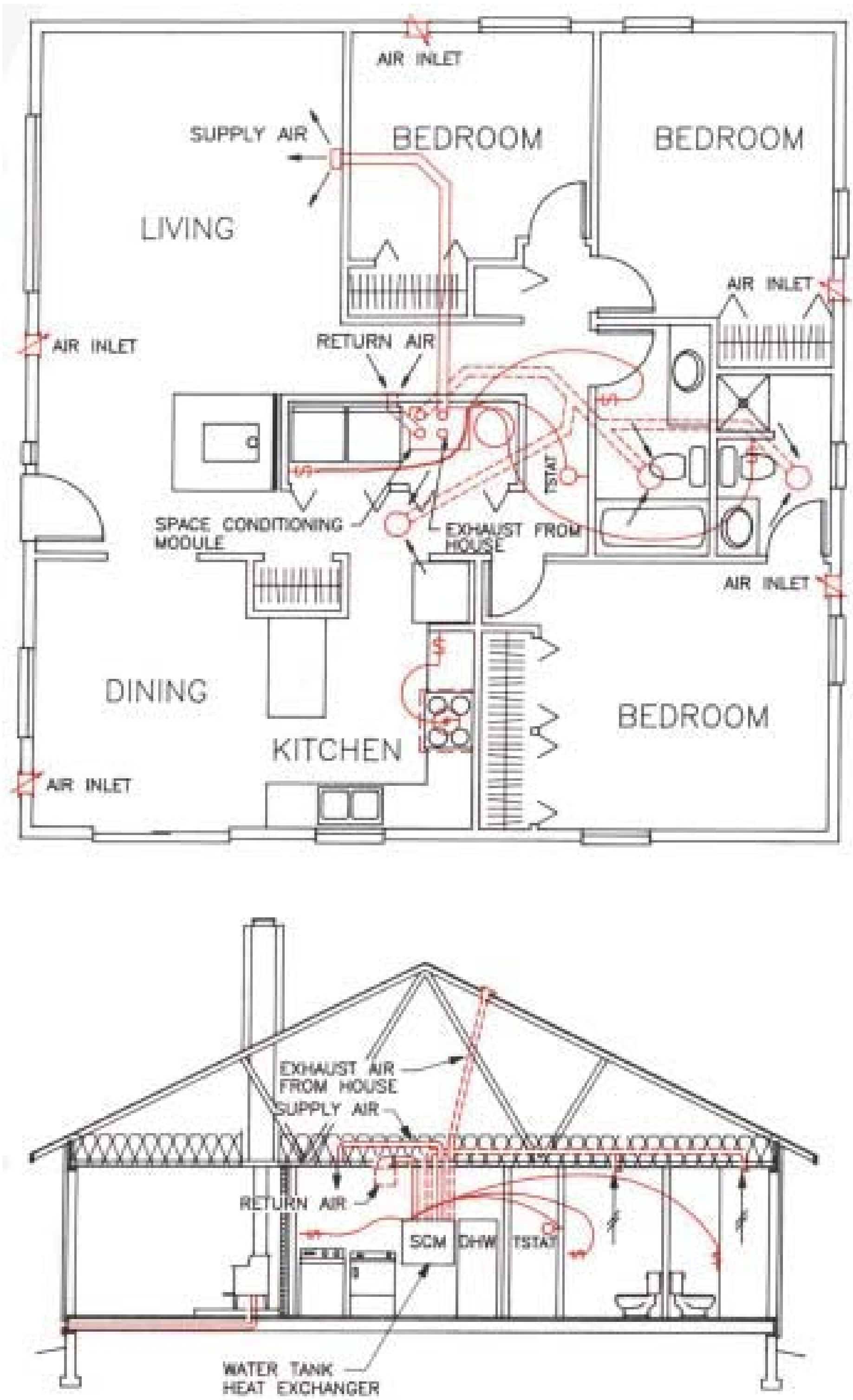


Figure 7P-2

EXHAUST AIR HEAT PUMP: WATER HEATING MODE

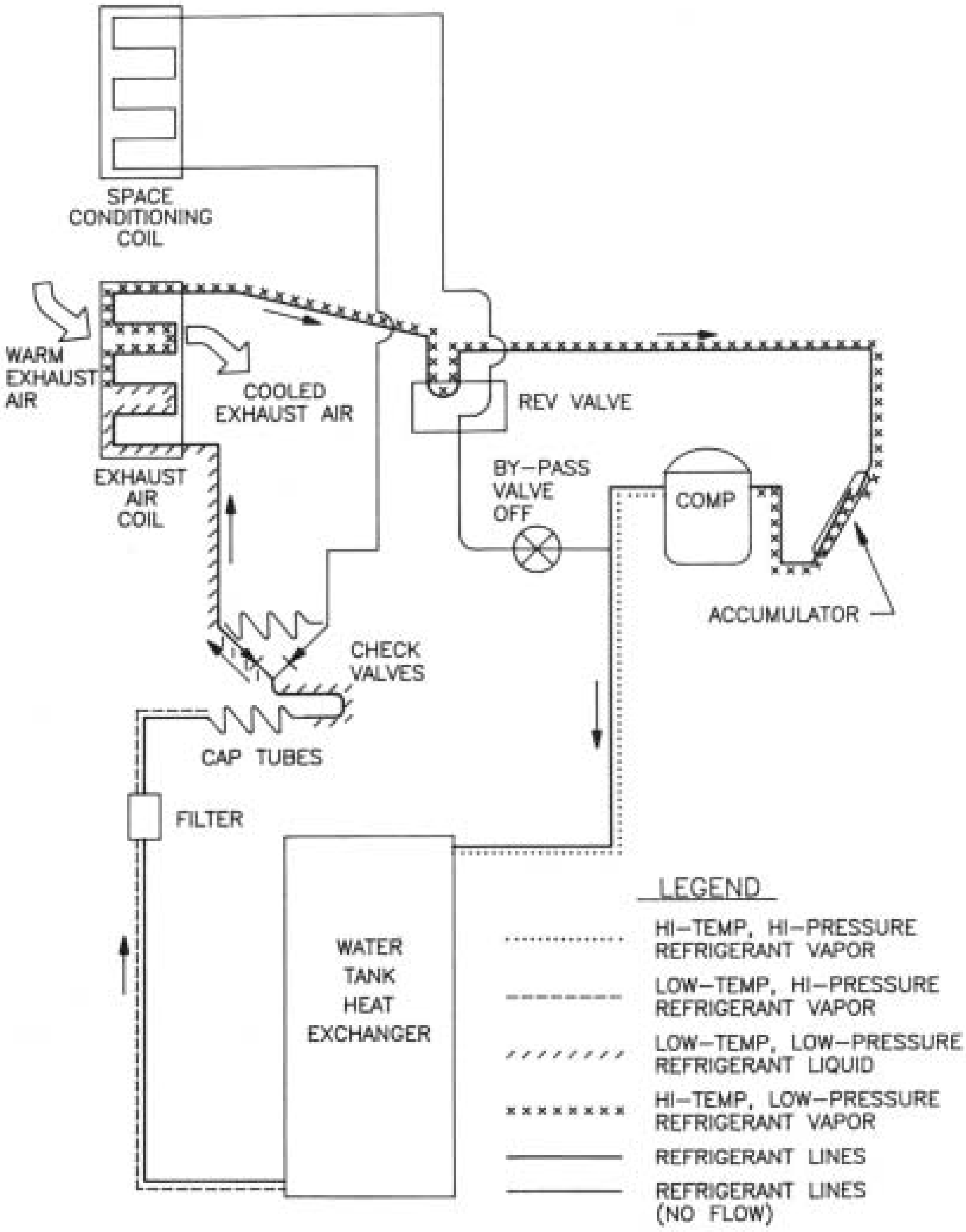


Figure 7P-3
EXHAUST AIR HEAT PUMP: SPACE HEATING MODE

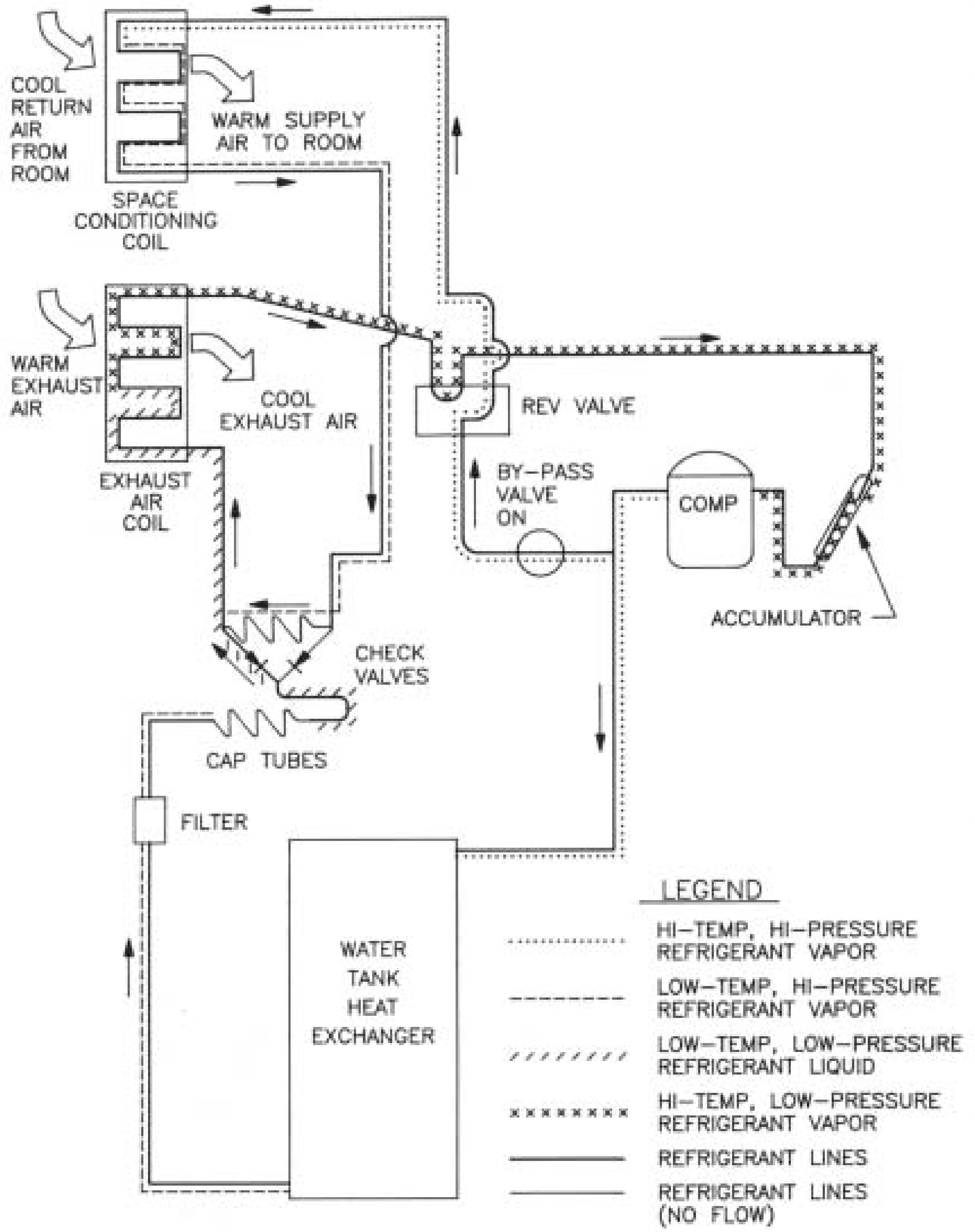


Figure 7P-4
EXHAUST AIR HEAT PUMP: STAGE 1 COOLING

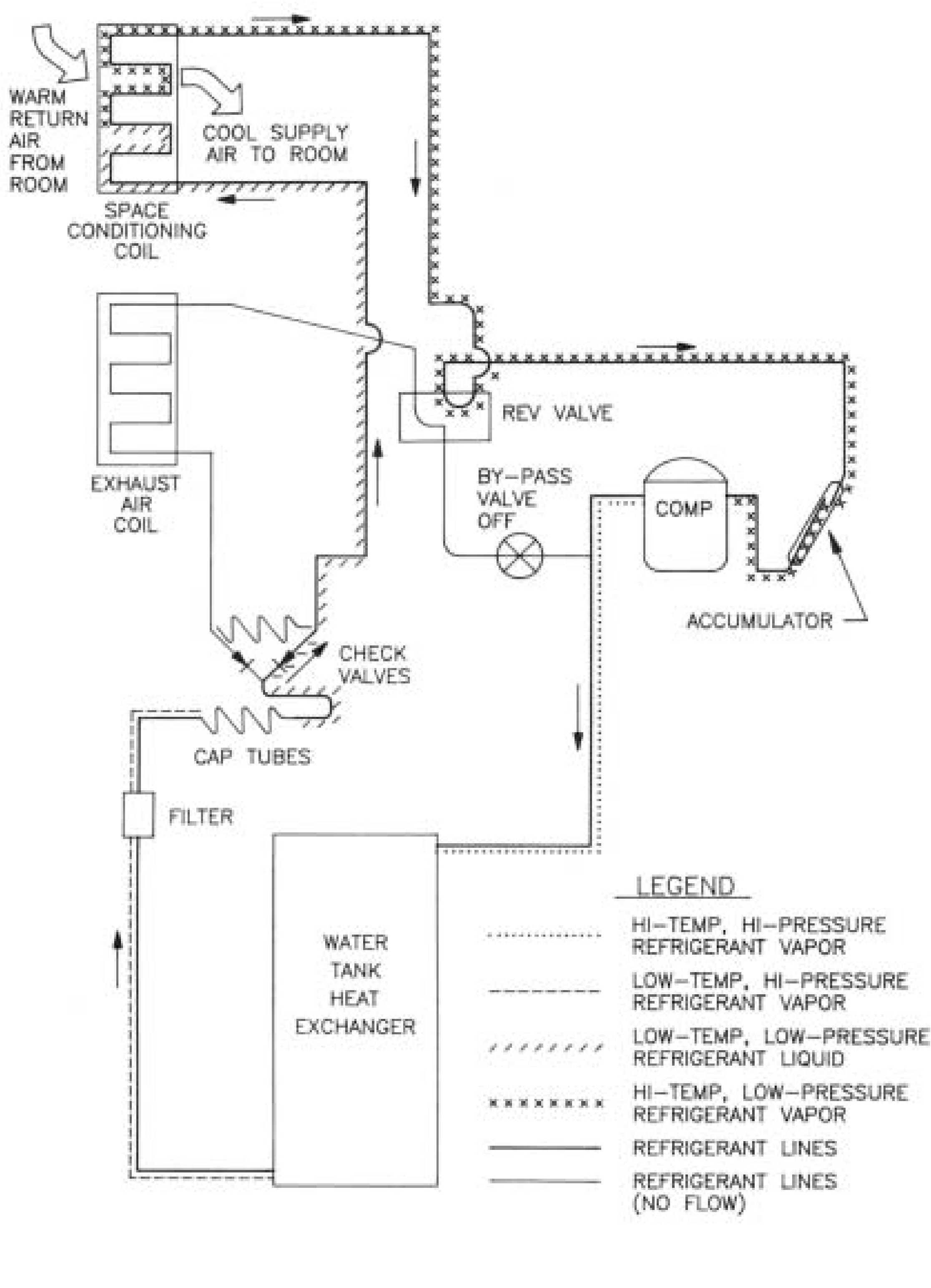
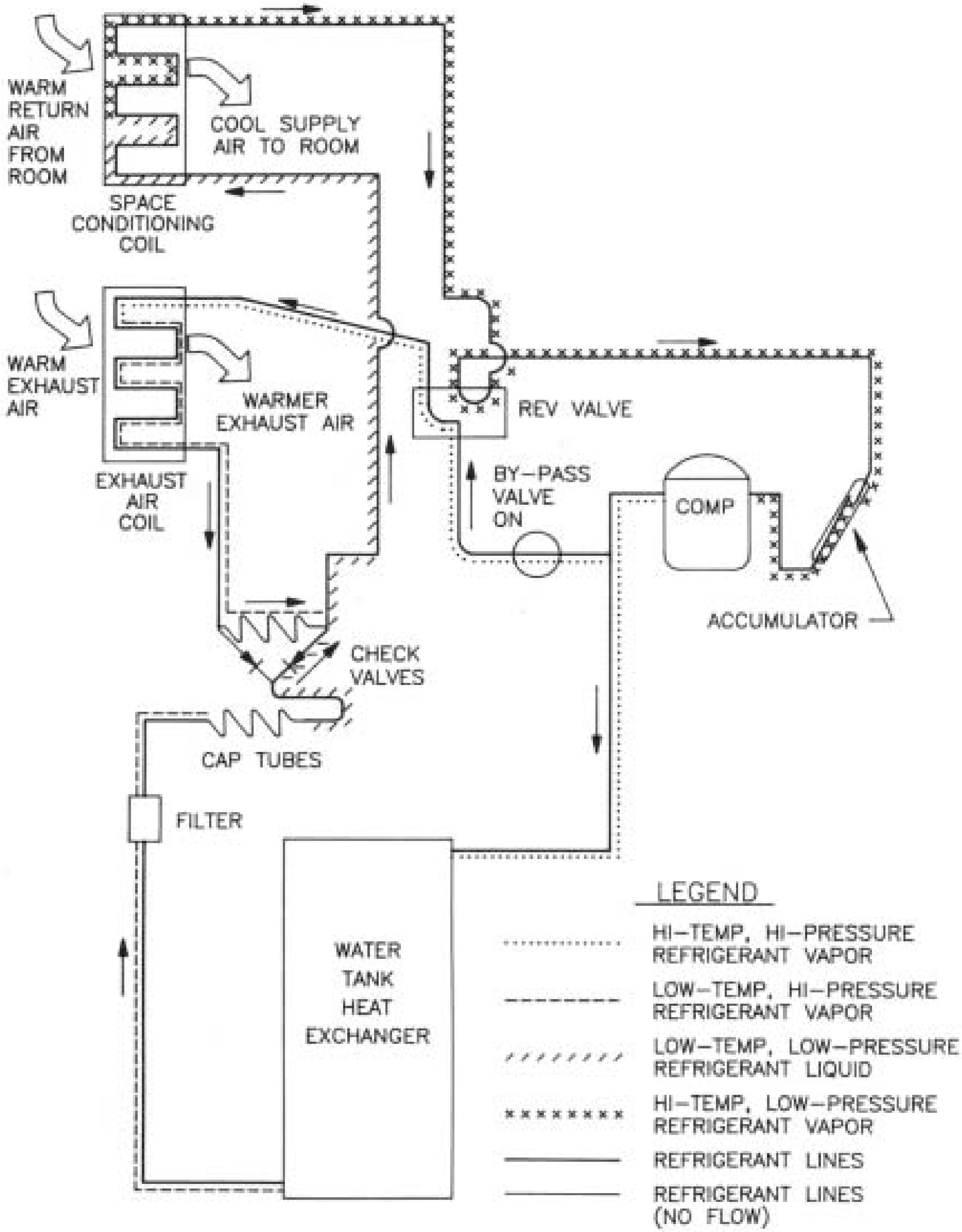


Figure 7P-5
EXHAUST AIR HEAT PUMP: STAGE 2 COOLING



Chapter 8

Combustion Appliance Installer

Many Super Good Cents homes have fireplaces or wood stoves. Wood stove dealers usually install stoves themselves or contract with an experienced wood stove installer. Fireplaces may be constructed by a mason. Some homes have zero clearance or gas fireplaces.

Combustion appliances must meet Super Good Cents requirements that help minimize the potential for combustion byproducts to enter living spaces. Unvented combustion devices are not allowed in Super Good Cents homes.

FIREPLACES: SOLID FUEL-BURNING AND GAS

1994 LTSGC 2.6

Flue Dampers

Solid fuel-burning fireplaces must have tight-fitting flue dampers with accessible controls. Tight flue dampers for solid fuel fireplaces help minimize entry of flue odors into a home when the fireplace is not in use. Gas fireplaces do not have closeable flue dampers. They must meet venting requirements of the Uniform Mechanical Code.

Combustion Air Intake to Firebox

Super Good Cents specifications require that fireplaces draw combustion air from outside the building directly to the firebox. For manufactured fireplaces, the combustion air supply must be the size specified by the manufacturer, but must not be less than 4 inches in diameter or more then 20 feet in length. For site-built fireplaces, combustion air intake area must be at least 4 inches in diameter and not more than 20 feet in length. The combustion air inlet to a fireplace should be at the front of the firebox, but inside the glass doors.

Tight-Fitting Doors

Fireplaces must have closeable doors. Fireplace doors reduce the volume of heated room air (excess air) that is drawn up the chimney, providing significant energy savings. Doors also help prevent backdrafting of combustion byproducts into the room and keep flue odors out of the home when the fireplace is not in use.

Wood Stoves

Combustion Air Intake to Firebox

The stove must allow ducting of primary combustion air from outside the building directly to the firebox. Many stove manufacturers provide listed kits for direct combustion air. Mobile home-approved wood stoves are OK. They have the same combustion air requirement.

Wood stoves that draw primary combustion air from the room or from a hole in the floor near the front of the stove are not permitted in Super Good Cents homes.

PRESSURE DIAGNOSTICS ARE RECOMMENDED WHEN COMBUSTION DEVICES ARE INSTALLED IN TIGHT HOMES WITH OTHER MECHANICAL SYSTEMS

Many fireplace doors and flue dampers simply are not tight, and many wood stoves take secondary and tertiary combustion air from the home.

It is critical to occupant health and safety that mechanical systems in homes do not create negative pressure environments in the combustion appliance zone. Pressure diagnostics can be used to determine whether combustion appliances are subjected to environments where they become “make-up air vents” for other mechanical systems in tight Super Good Cents homes.

Pressure diagnostics require use of a digital manometer. The manometer is set up to read air pressure in the combustion appliance zone with reference to outside air pressure. Other house systems are turned on, one by one, to assess their individual and cumulative effects.

Contact your local utility or state technical assistance provider for more information on diagnosing negative pressure environments.

Chapter 9

Air Tightening Specialist

Air leakage can account for 30 to 40 percent of home heat loss. That is why the Super Good Cents program emphasizes air leakage control. Good air leakage control means lower heating bills and better comfort.

You can choose from two approaches to air leakage control: Standard Air Leakage Control (right construction) and Advanced Air Leakage Control (super-tight construction).

In addition to caulking and sealing that are part of Standard Air Leakage Control, Advanced Air Leakage Control creates a "continuous air barrier," usually at interior wall, ceiling, and floor surfaces.

The many steps in each air leakage approach add up to a conservation measure as important as insulation, good windows, insulated doors, efficient heating systems, and solar features.

Air leakage control may be accomplished in many ways. One way is to have subcontractors seal joints and penetrations they create in their work: Framers seal framing joints and seams, electrical contractors seal electrical penetrations, plumbers seal plumbing penetrations, and HVAC contractors seal penetrations for ducts and other air leakage sites in the heating system. Another way is to make one person—the air tightening specialist—responsible for all air sealing. Air tightening specialists are most effective when they focus on two stages in the construction sequence: 1) the rough framing stage before walls are insulated and 2) after the drywall is hung.

STANDARD AIR LEAKAGE CONTROL MEASURES AT ROUGH FRAMING STAGE

1994 LTSGC 2.3.1

Floors

_____ Plumbing penetrations
_____ Tub plumbing penetration (see Chapter 6 for details)
_____ Electrical penetrations
_____ Heating system penetrations
_____ All duct joints and seams
_____ Joints around masonry
_____ Heated basement:
    _____ Mudsill sealed to stem wall
    _____ Rim joist sealed to mudsill and flooring
_____ Upper floor rim joists

Walls Between Heated and Unheated Spaces

Penetrations through the top and bottom plates of all walls and through siding and sheathing

________ Electrical penetrations
________ Plumbing penetrations
________ Telephone penetrations
________ TV cable penetrations
Penetrations around
________ through-the-wall vents
________ Wall to floor joint
Penetrations at partition intersections
________ with exterior walls
________ Horizontal top plate joint
________ Window and door rough openings
________ Exterior door thresholds

Ceilings Between Heated and Unheated Spaces

Penetrations

______ Attic hatch (if inside heated space)
______ Skylight seams and joints
______ IC recessed lights

STANDARD AIR LEAKAGE CONTROL MEASURES AFTER DRYWALL

Walls Between Heated and Unheated Spaces

______ Switch boxes sealed to drywall
______ Outlet boxes sealed to drywall
______ Plumbing penetrations sealed
Through-the-wall air vent
______ penetrations sealed
______ Beam pockets sealed

Ceilings Between Heated and Unheated Spaces

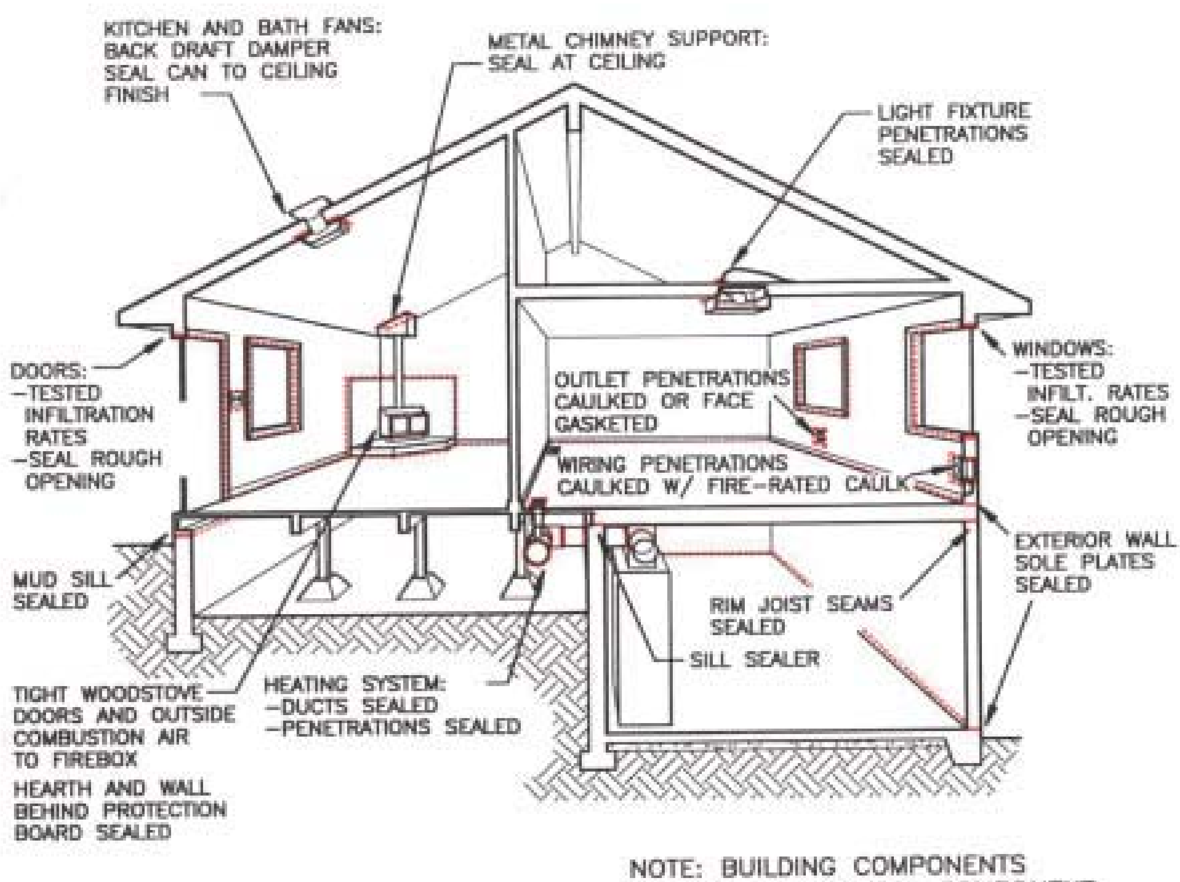
______ Light box penetrations sealed to drywall
______ Recessed light cans sealed to drywall
______ Fan cans sealed to drywall

TIP: The tub penetration is difficult to seal once the plumbing and tub are in place. It is best handled by the plumber during tub installation. See Chapter 6 for tub sealing details. If gaskets are not used, install a separate cover around the pipes by boxing them in with framing and sheathing to completely seal the opening.

TIP: Framers can seal the rim joist to the mudsill after the rim is in place and floor layout marks have been completed, just before floor joists are installed. See Chapter 4 for floor framing and insulation details. Once wall framing begins, rims can quickly be covered by sheathing. The air tightening specialist must seal the rim before it is covered. Typical sealing materials are caulking and expanding foam.

Figure 9A shows air sealing sites.

Figure 9A
STANDARD AIR LEAKAGE CONTROL: PLACES TO SEAL



NOTE: BUILDING COMPONENTS TO MEET STRUCTURAL COMPONENT FORMALDEHYDE STANDARDS:
"HUD APPROVED"
"EXTERIOR"
"EXPOSURE 1"

ADVANCED AIR LEAKAGE CONTROL MEASURES

1994 LTSGC 2.3.2; Appendix A 3.3

If you qualify for the Super Good Cents program using Advanced Air Leakage Control, specifications require a blower door test to verify house tightness. The test measures building air leakage and identifies air leakage locations.

Advanced Air Leakage Control With Heat Recovery Ventilation

In some cases, even if advanced air leakage is not used to qualify the home, it may be an "associated measure" for optional heat recovery ventilation. When Advanced Air Leakage Control functions as an associated measure, prescriptive air sealing measures are installed and inspected, but no blower door test is required. Heat recovery ventilation systems are described in Chapters 5 and 7.

Blower Door Testing Standard

1994 LTSGC Appendix C

Blower door tests for Super Good Cents qualification should be conducted by trained blower door technicians. Where no local testing contractors are available, your Super Good Cents representative may be able to help you track down someone who can do the testing.

Appendix C of the 1994 Super Good Cents specifications gives the required protocol for a valid test to certify Advanced Air Leakage Control.

Blower Door Test Procedure

Most blower door manufacturers supply computer software with their doors for determining air leakage rates. In most cases, the computer printout and a cover letter are sufficient to demonstrate to the Super Good Cents representative that you used the correct testing protocol.

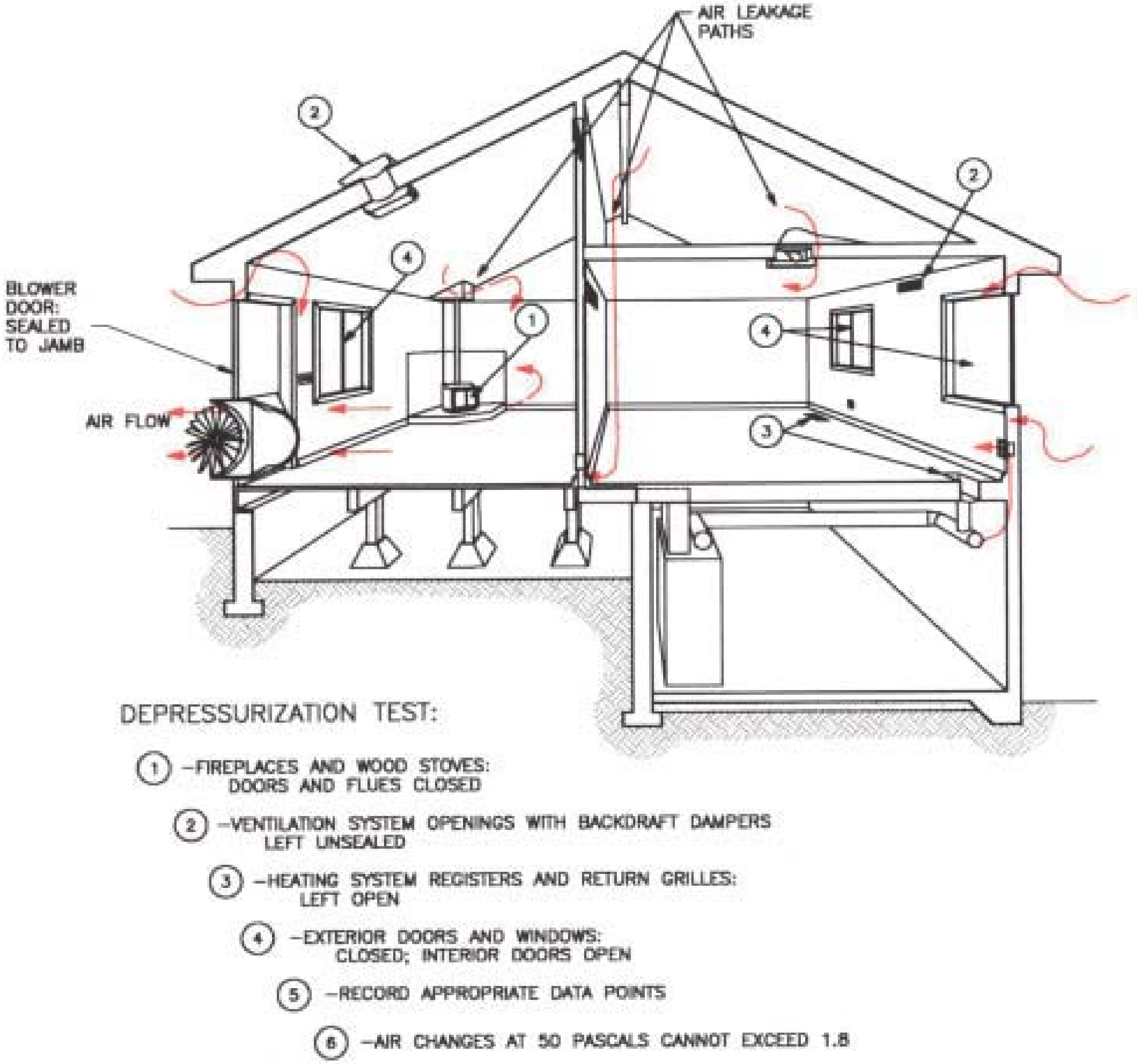
Remember: House certification depends on blower door test results. Testing must be done carefully.

Figure 9B shows how a blower door test works.

Super Good Cents Advanced Air Leakage Control Performance: 1.8 ACH at 50 Pascals

When you qualify a home with Advanced Air Leakage Control measures, the blower door test must indicate 1.8 air changes per hour (ACH) or less at 50 Pascals air pressure difference. If the home fails the test, additional house tightening usually

Figure 9B
BLOWER DOOR TEST



brings the home into compliance with the performance standard. The blower door, used in conjunction with smoke pencils or other leak detectors, helps find leaks that may have been missed during construction.

What Is a Continuous Air Barrier?

Many materials are effective barriers to air leakage. Continuous air barriers simply join air barrier materials together to create a barrier unbroken over the entire building envelope. Figure 9C shows how an air barrier can be made continuous throughout the building envelope.

Commonly used air barrier materials include drywall, sheathing, plastic sheets, glass, framing materials, and doors.

The trick is to use sealants and gaskets to join these materials into a continuous air barrier.

Is an Air Barrier a Vapor Retarder?

An air barrier prevents air movement through cracks and crannies of the building envelope. A vapor retarder blocks diffusion of moisture directly through a building material.

Some air barriers also function as vapor retarders. It depends on their "perm rating," a measure of resistance to moisture transfer. Polyethylene has a low perm rating. That makes it a good vapor retarder.

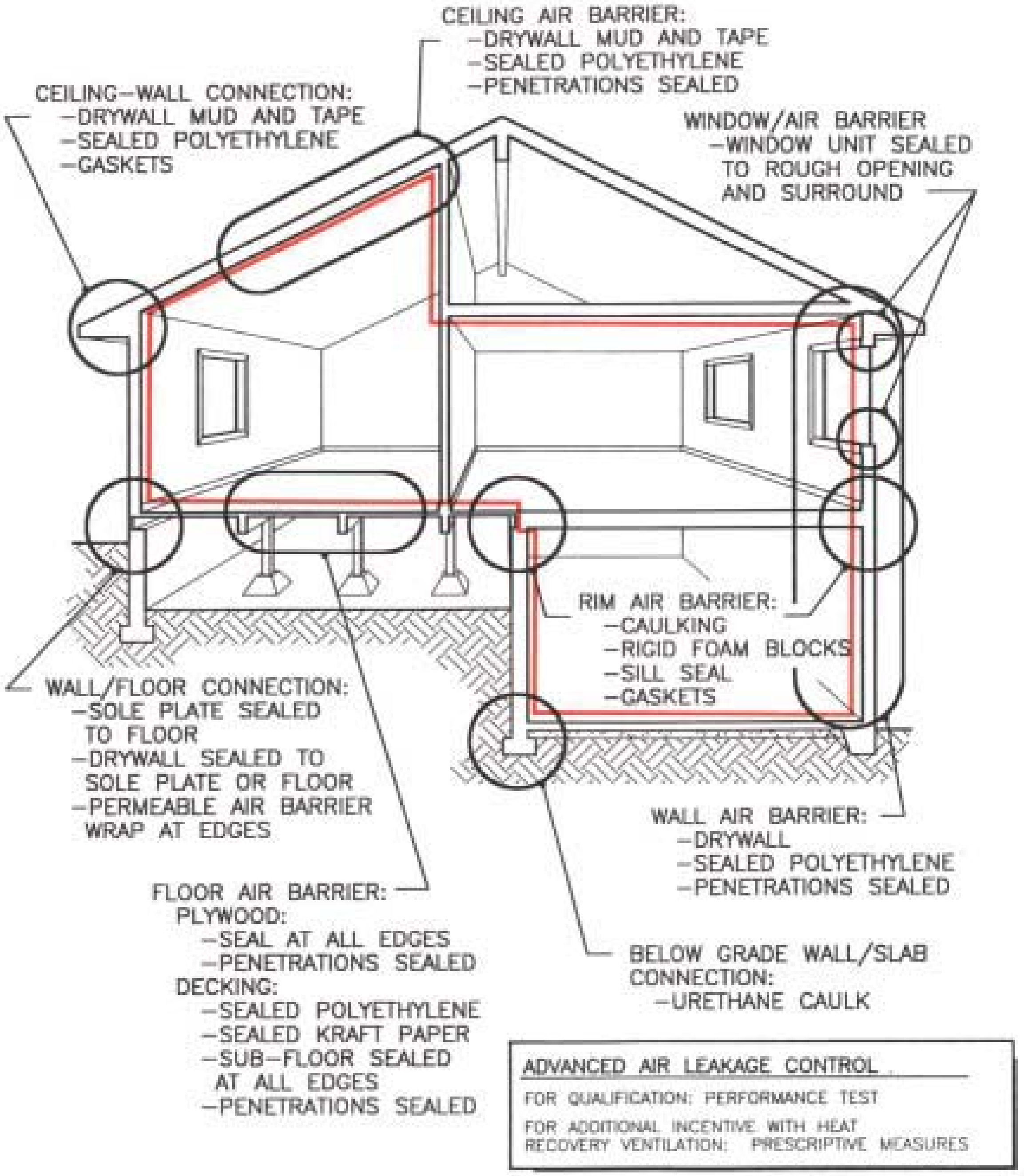
To make a good air and vapor barrier with polyethylene sheets, make a continuous seal with them, and join them continuously with other continuous building components. You also must install and fasten the sheets strongly enough to resist normal construction abuse, wind, and air pressures induced by a blower door test, if applicable.

Rigid foam boards typically have a low perm rating. To achieve the continuous air barrier required by Advanced Air Leakage Control, place rigid foam boards on the interior side of the wall, sealed together and connected to other building components.

The "Advanced Drywall Approach" uses gaskets or otherwise seals drywall to building components to form a continuous air barrier. Since drywall has a high Perm rating, you must use another material for your vapor retarder. Builders typically use tested vapor retarder paint, faced insulation, or polyethylene.

Rule of thumb: If a material has a perm rating of 1 or lower, it makes a good vapor retarder.

Figure 9C
CONTINUITY IN AN AIR BARRIER



Approaches to Advanced Air Leakage Control

Any method that tightens the building envelope to 1.8 ACH50 is OK. Most approaches to Advanced Air Sealing start with Standard Air Leakage Control measures, then go the next step to make the air barrier continuous.

Continuity in an air barrier can be achieved in a number of ways:

- Advanced Drywall Approach - A drywall gasketing system
- "Simple*cs" - A simple caulk and seal system described below
- Polyethylene air/vapor barrier system
- Interior rigid foam sealing system

You can mix and match these systems. Just keep the idea of continuity in mind.

ADVANCED DRYWALL APPROACH

The idea behind the Advanced Drywall Approach is to use materials you are already using in the house (such as drywall, sheathing and concrete) as your continuous air barrier. Use sealants and gaskets to join materials together to form the barrier.

The main air barrier material in walls and ceilings is drywall. The typical air barrier material in floors is plywood or other continuous sheathing materials.

Figures 9D and 9E show versions of a drywall gasketing system used to block air infiltration paths from partition walls into exterior wall cavities and from wall cavities into attic spaces or vaults. After you tie the drywall system to the frame, tie the framing to a continuous floor and ceiling air barrier.

The air tightening specialist can apply gaskets as part of rough framing caulking and sealing. Troublesome areas include soffits, stairwells, and tub enclosures. Visualize air leakage paths that these constructions create to help you effectively apply gaskets.

You may use continuous beads of drywall adhesive instead of gaskets, as long as the drywall installer applies them just before each sheet is hung. Figures 9M through 9S show other ways to provide continuity in Advanced Drywall Approach applications.

SIMPLE CAULK AND SEAL SYSTEM - "SIMPLE*CS"

Simple*cs is a simple caulk and seal system that is a variation of the Advanced Drywall Approach. Simple*cs recognizes that sheet materials of the building envelope make up 90 percent of the air barrier and focuses on connecting components. It simplifies the process by placing all air sealing points inside the building. That way, one person can do most air sealing in a warm, dry environment and nearly all at one time.

Figure 9D
DRYWALL SEALING AT INTERSECTIONS OF INTERIOR/EXTERIOR WALLS AND WALLS/CEILINGS

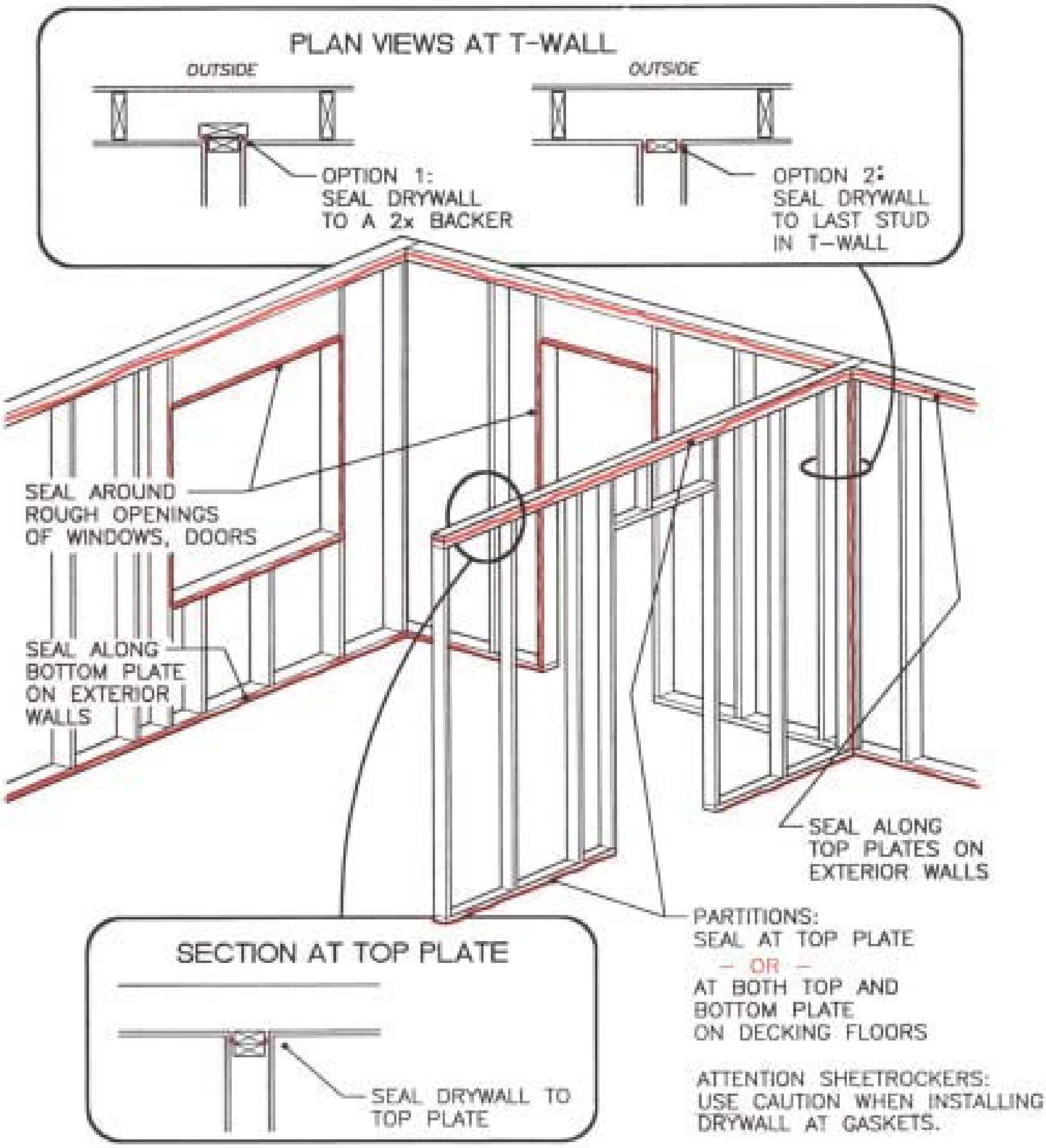
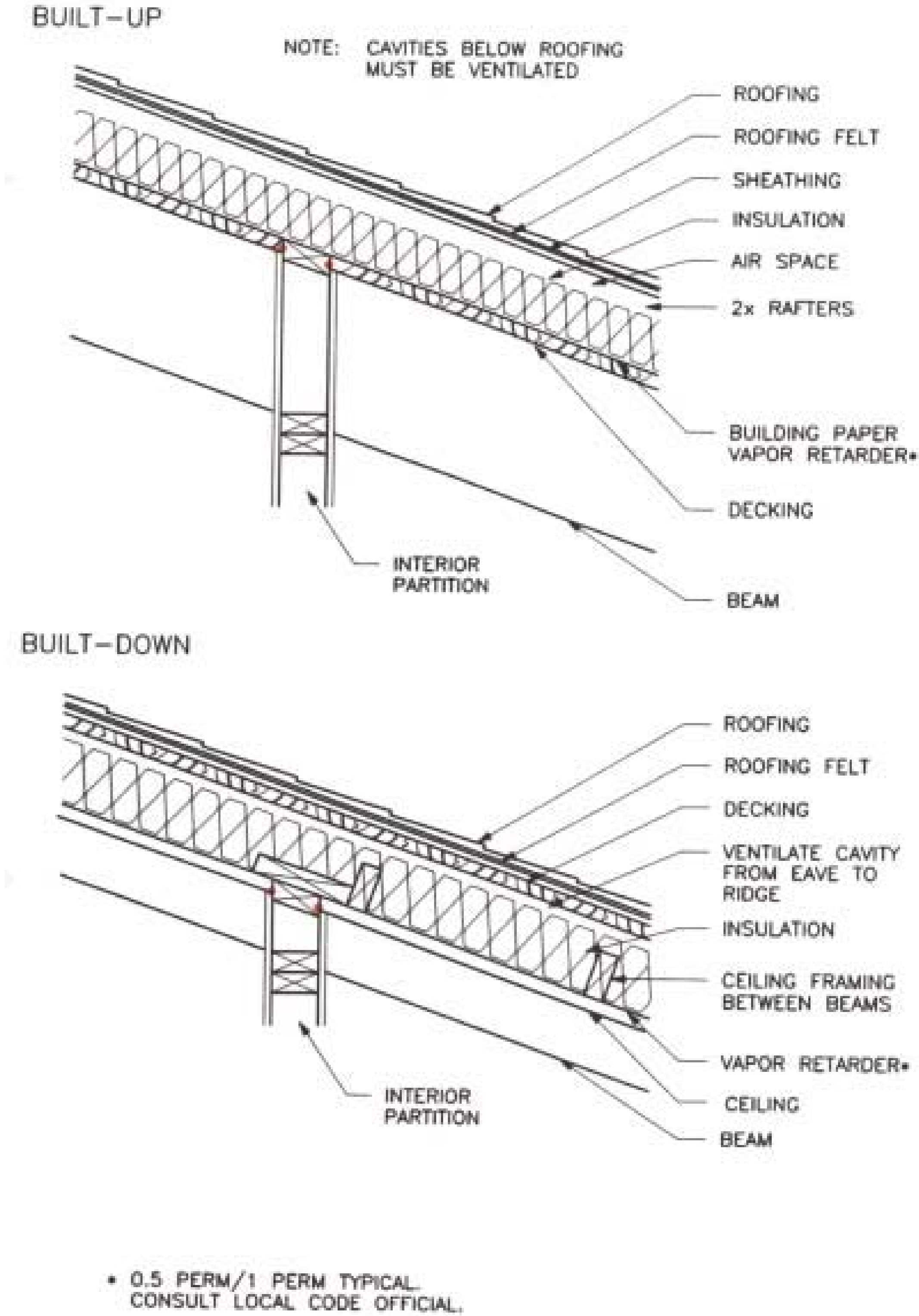


Figure 9E
DRYWALL SEALING AT WALL/VAULT INTERSECTION



Start by examining the house plan. Identify and highlight air leakage paths. Sort items that need sealing into three groups: major structural openings and intersections, major service penetrations, and other penetrations. Determine sealing methods, sealing materials, and timing. Identify who will be responsible for what. Planning improves effectiveness of air sealing and reduces interruption to the normal flow of work.

Ask your Super Good Cents utility or state technical assistance provider for more information on Simple*cs.

POLYETHYLENE AIR AND VAPOR BARRIER

Polyethylene (often referred to as "poly") has been used for many years in homes in Canada and the U.S. The perm rating of 6-mil-thick poly is 0.06. It is suitable for use as a vapor retarder as well as an air barrier.

When you use poly as an air barrier, seal or tape the sheets together and seal them to other building components to achieve air barrier continuity. If poly serves only as a vapor retarder, you do not need this extra sealing.

Install polyethylene sheets after drywall backing is in place but before you install drywall. Seal the poly with acoustical sealant and staple the poly through the sealant to hold the seal in position. Or use special (extra sticky) tape formulated to stick to polyethylene.

Ceiling Poly

To achieve a continuous ceiling air barrier, staple ceiling poly to ceiling framing and seal the poly to interior and exterior wall top plates. Apply sealant along the plate. Double back the poly and staple it to the sealant. Leave plenty of slack at corners so drywall can go in without ripping the air/vapor barrier. See Figure 9F.

Other options, also shown in Figure 9F, use "connector strips" to achieve a continuous ceiling air barrier. These options require cooperation of the framers.

Wall Poly

Apply sealant over the ceiling poly at the top plate, to the frame around window and door rough openings, and to the bottom plate. Lay sheets over the sealant and securely staple poly at framing members. See Figures 9G and 9H. Figure 9I shows details at rims, corners, and ceilings.

Figure 9F
POLY AIR BARRIER AT TOP PLATE

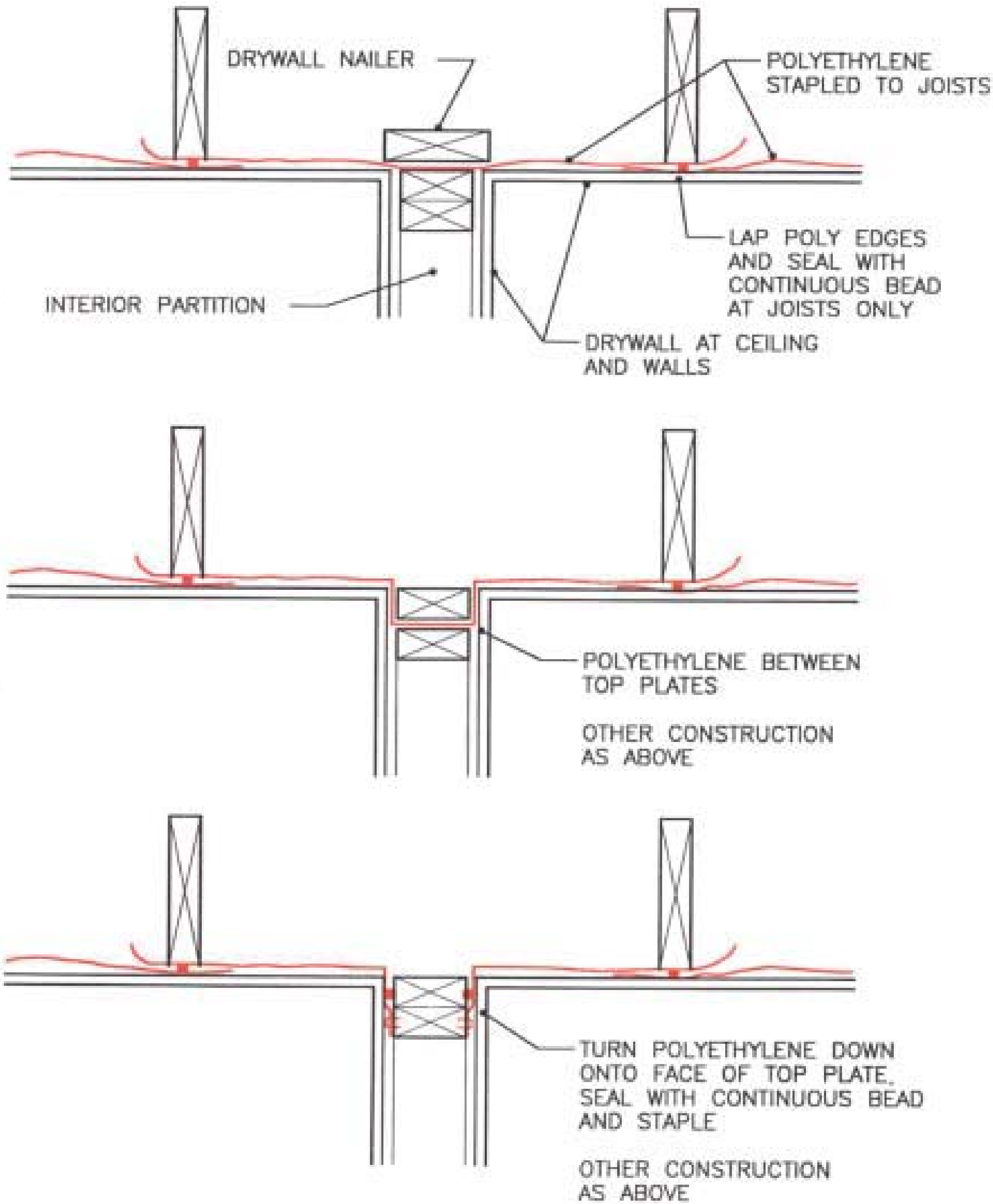


Figure 9G
SEALING POLY SHEETS

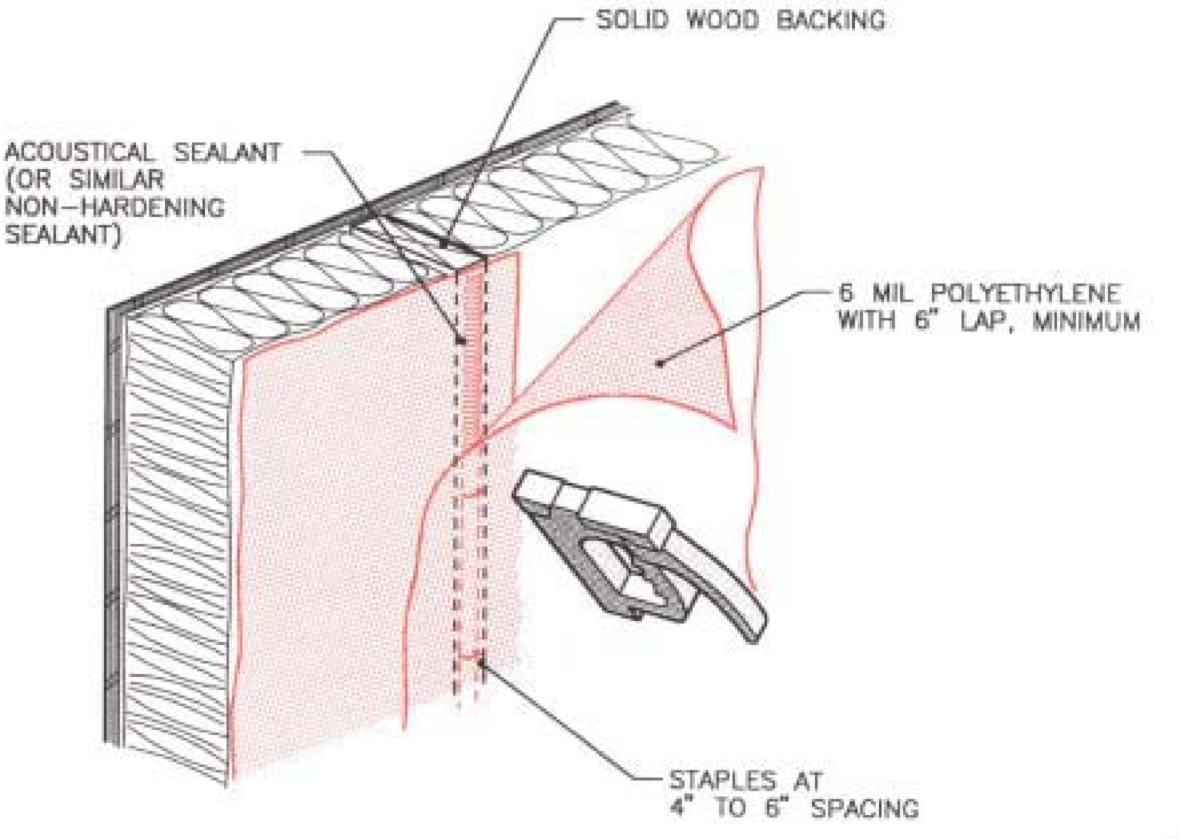


Figure 9H
POLY AIR BARRIER AT CORNER AND INTERIOR/ EXTERIOR WALL INSTERSECTION

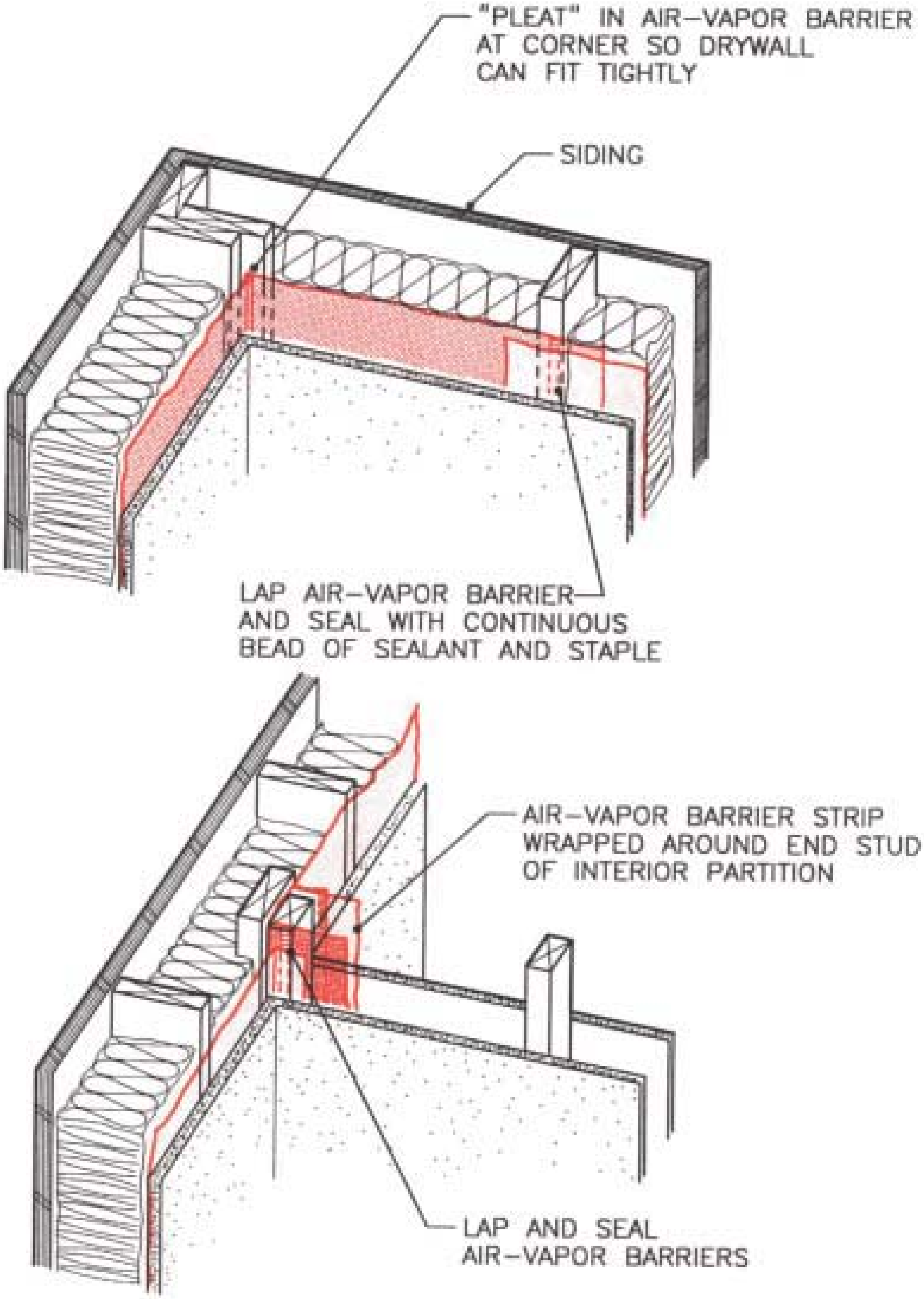
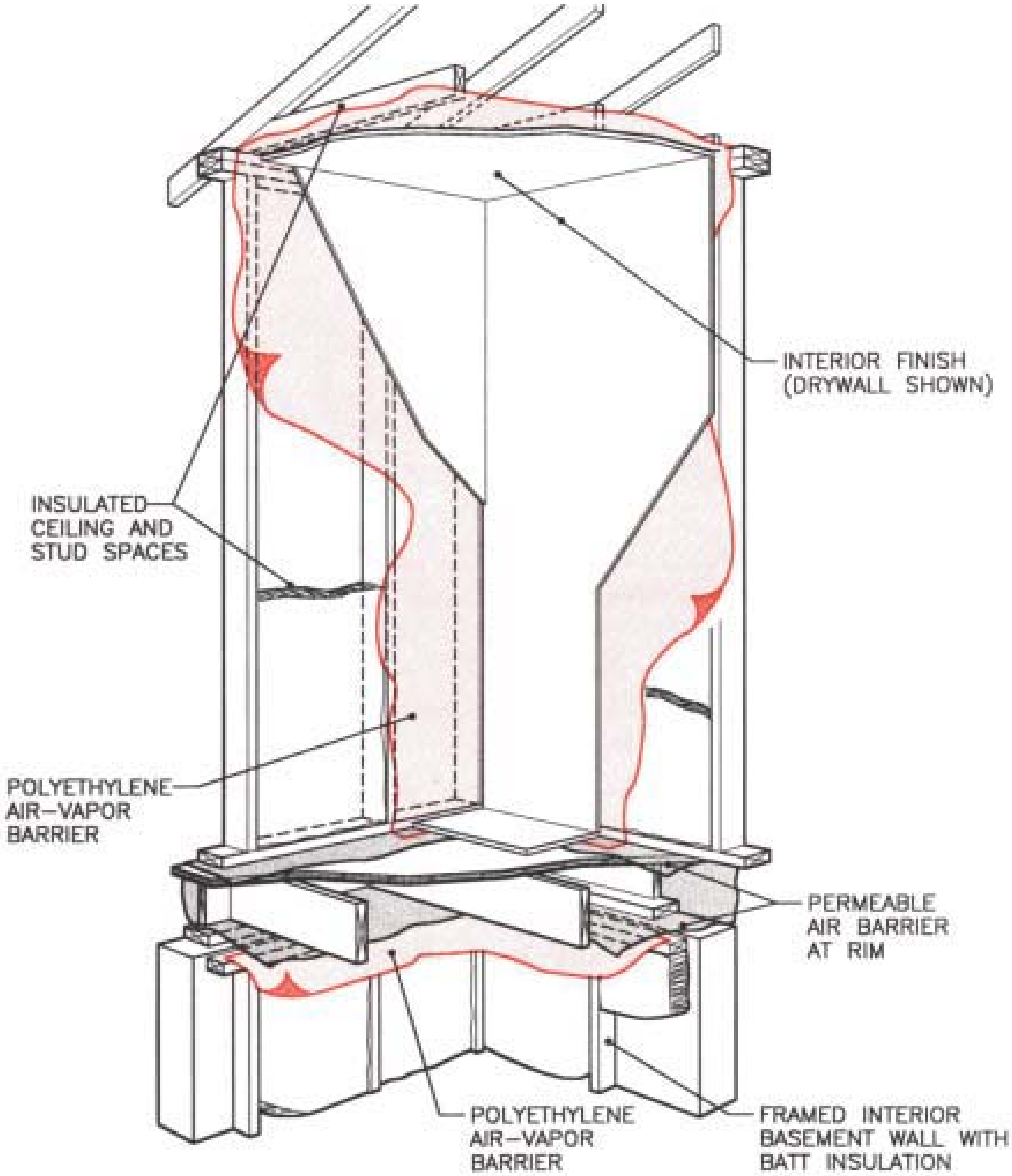


Figure 9I

POLY AIR BARRIER CONNECTIONS AT RIMS, CORNERS, AND CEILINGS



Carefully make cutouts at switch and outlet boxes and carefully stretch the poly around the box. Make the cutout slightly smaller than the box dimensions for a tighter connection. Some people tape the poly to the sides of the boxes for a complete seal.

Make cutouts at window and door rough openings, and lap trimmed poly into the rough opening. Later, the window wrap material will be sealed to the poly lap and to the window frame. See Figure 9J.

The air/vapor barrier is now continuous over ceiling and wall surfaces. Lapping and sealing the poly to a continuous floor air barrier completes the package.

A Warning About Poly Ceiling Air/Vapor Barriers

Once poly is in place, the normal practice is to begin drywall installation. Drywall is hung, taped, and textured. When the drywall contractor finishes, the insulation contractor comes back and insulates the attic.

IF YOU USE POLY IN THE CEILING, YOU MUST INSULATE THE CEILING BEFORE TAPING AND TEXTURING BEGIN. If the ceiling is not insulated, the poly vapor retarder will be cold. In cold weather, moisture released into the building during taping and texturing may reach its dew point at the ceiling. The uninsulated ceiling may actually become wet enough to fall down.

Insulating prior to taping and texturing keeps the poly vapor retarder warm. Released moisture will not reach the dew point in the ceiling, and you will not find the ceiling lying on the floor.

INTERIOR RIGID FOAM AIR BARRIER

To achieve a high wall R-value, you may need to apply rigid foam sheets over the wall framing in addition to the cavity insulation. If foam sheathing is applied to the interior surface of a wall, a few extra steps can create a continuous wall air barrier. The Advanced Air Leakage Control package is complete when the wall air barrier is finally connected to the floor and ceiling air barrier.

Blue, green, pink, and foil-faced foams have a perm rating of about 1. These materials can double as vapor retarders. White bead board typically has a perm rating of 2 or higher. It is not an acceptable vapor retarder. Figure 9K illustrates the rigid foam air barrier.

Special Framing Details

Interior rigid foam systems require special framing details at corners, partitions, and ceilings to provide the extra wide backing needed for a thicker wall finish. Attach nailers around openings and at corners to provide secure nailing for the drywall corner beads. See Figure 9L.

Figure 9J
POLY AIR BARRIER AT WINDOW ROUGH OPENING

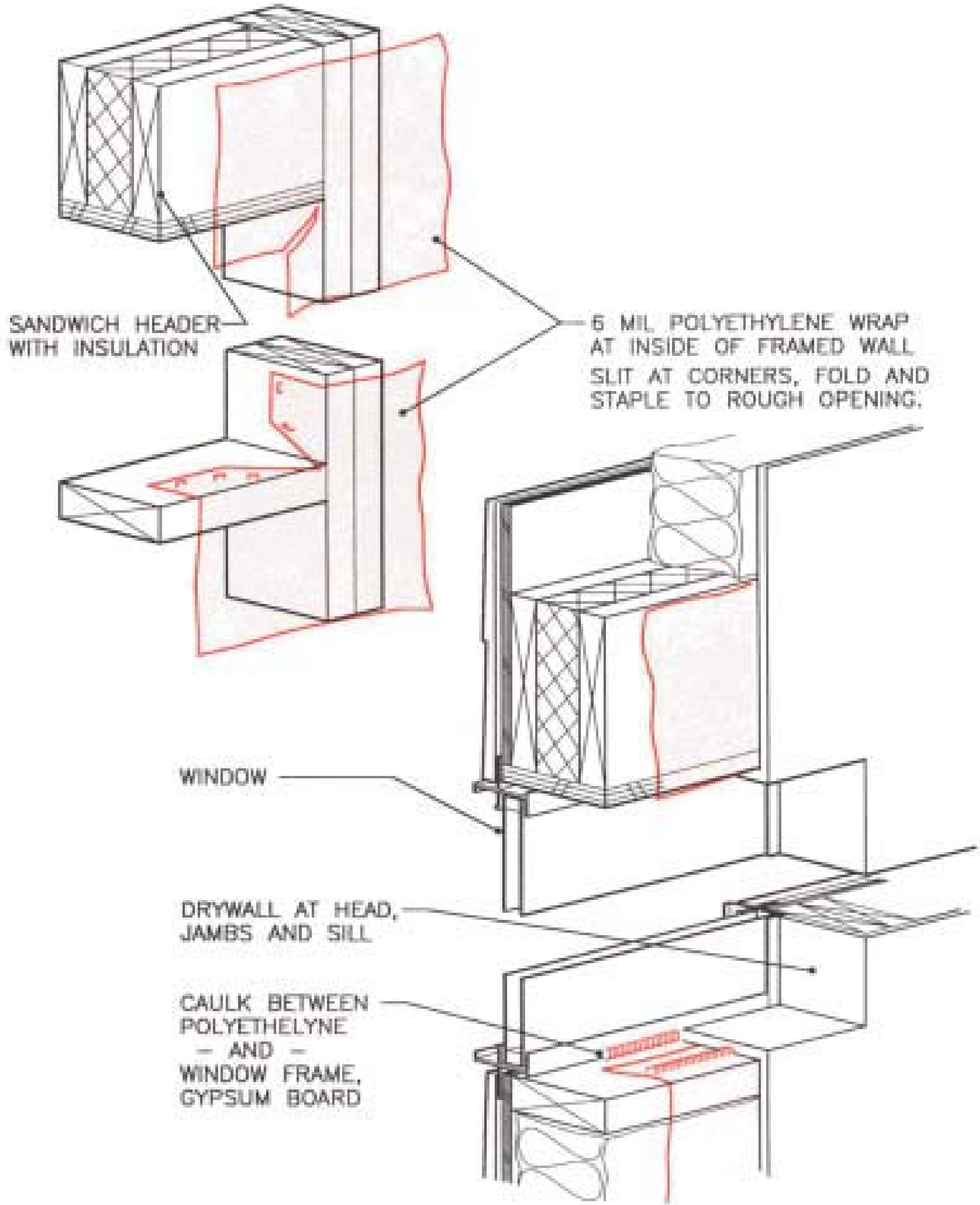


Figure 9K
INTERIOR RIGID FOAM AIR BARRIER

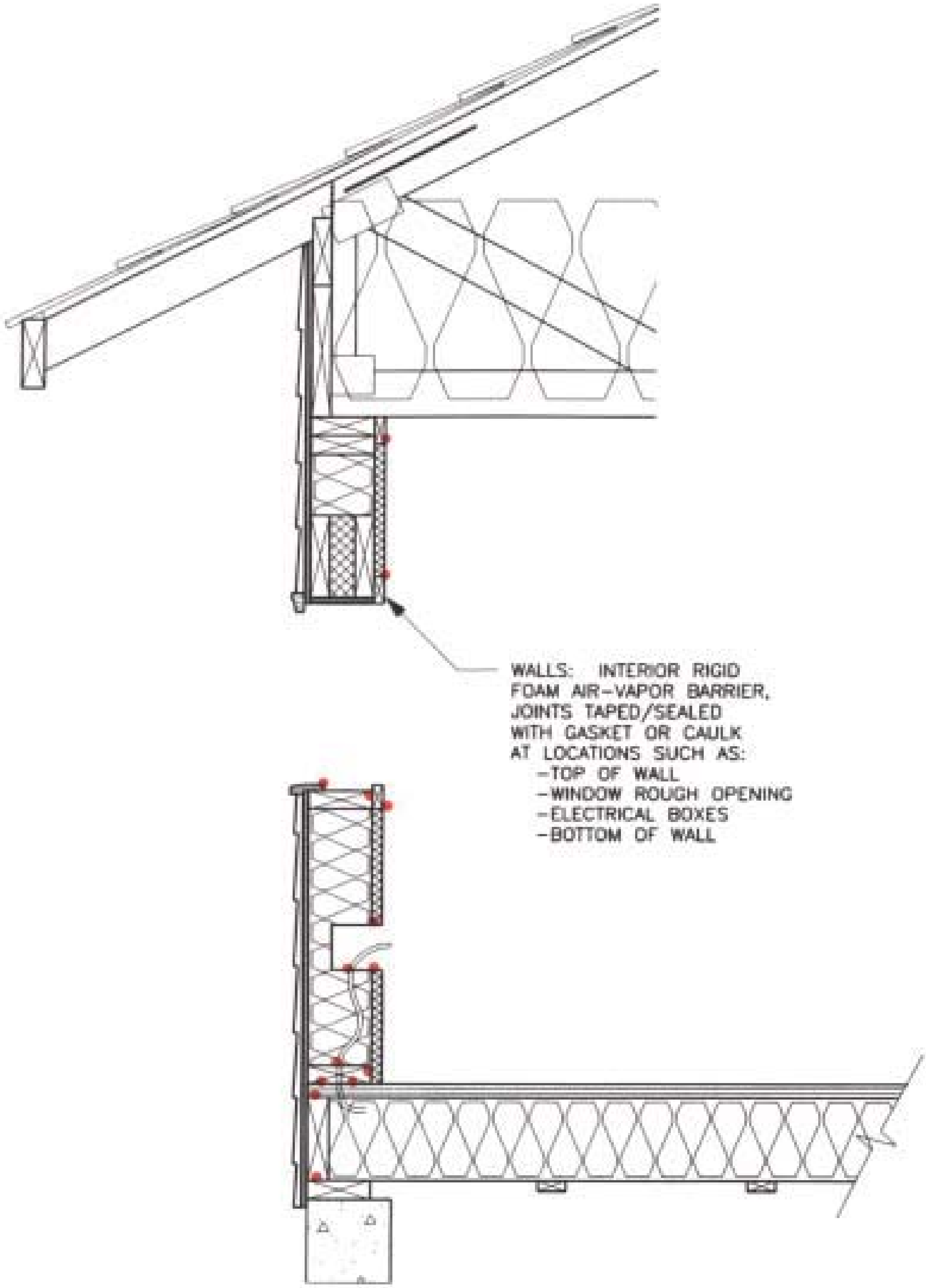
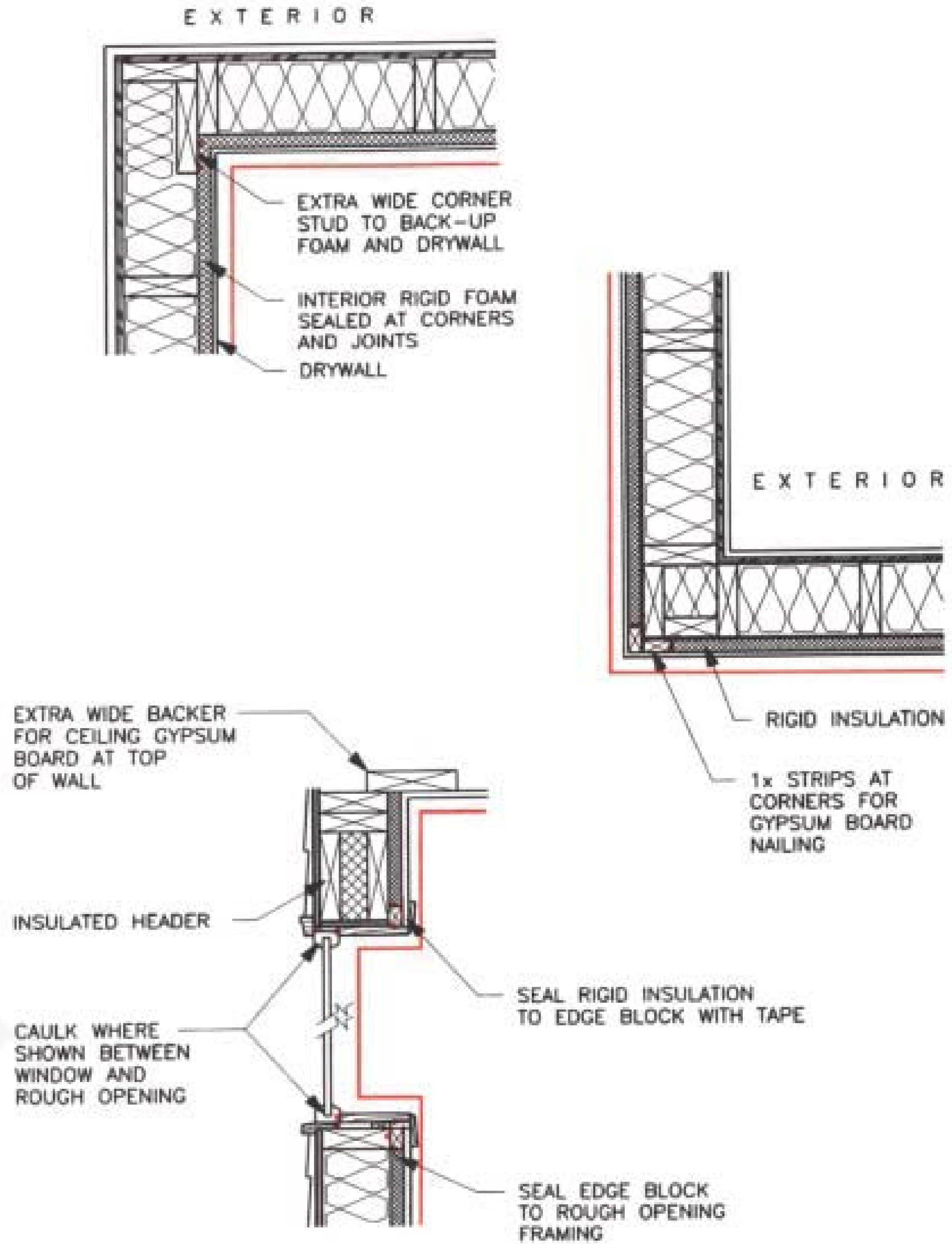


Figure 9L
INTERIOR RIGID FOAM FRAMING DETAILS



Special Electrical Box Adjustment

Let your electrical contractor know that you are using interior rigid foam. That way switch and outlet boxes can be set at the appropriate finish wall depth.

Other Effects of Thicker Interior Wall Cover

The thicker interior wall cover affects width of door jambs and window surrounds. It also may affect overall cabinet dimensions and blocking details for cabinets, curtain rods and closet poles.

Installing Rigid Foam Sheets

Install foam board just like drywall. Mark stud spacing on the floor. Snap stud lines onto the face of the foam. This makes the drywall contractor's job easier.

Seal end joints to the frame with caulk. Tape horizontal and vertical joints in the field. Caulk the bottom edge to the floor. See Figures 9K and 9L.

GET RID OF MOISTURE

The air barrier/vapor retarder systems discussed in this guide are so effective that high levels of humidity occur in the finish stages of construction, during drywall and painting. Natural air change rates are low. Open windows and use fans to move moisture out of the home.

Portable propane and fuel oil heaters release moisture during the combustion process. They are poor choices for drying homes with continuous air barriers. Electric heaters and large-capacity dehumidifiers remove moisture faster.

AIR BARRIER CONTINUITY AT DIFFICULT CONSTRUCTION JOINTS

Figures 9M through 9S show ways to maintain air barrier continuity at some of the more difficult construction joints.

Figure 9M
FLOOR SHEATHING AIR BARRIER

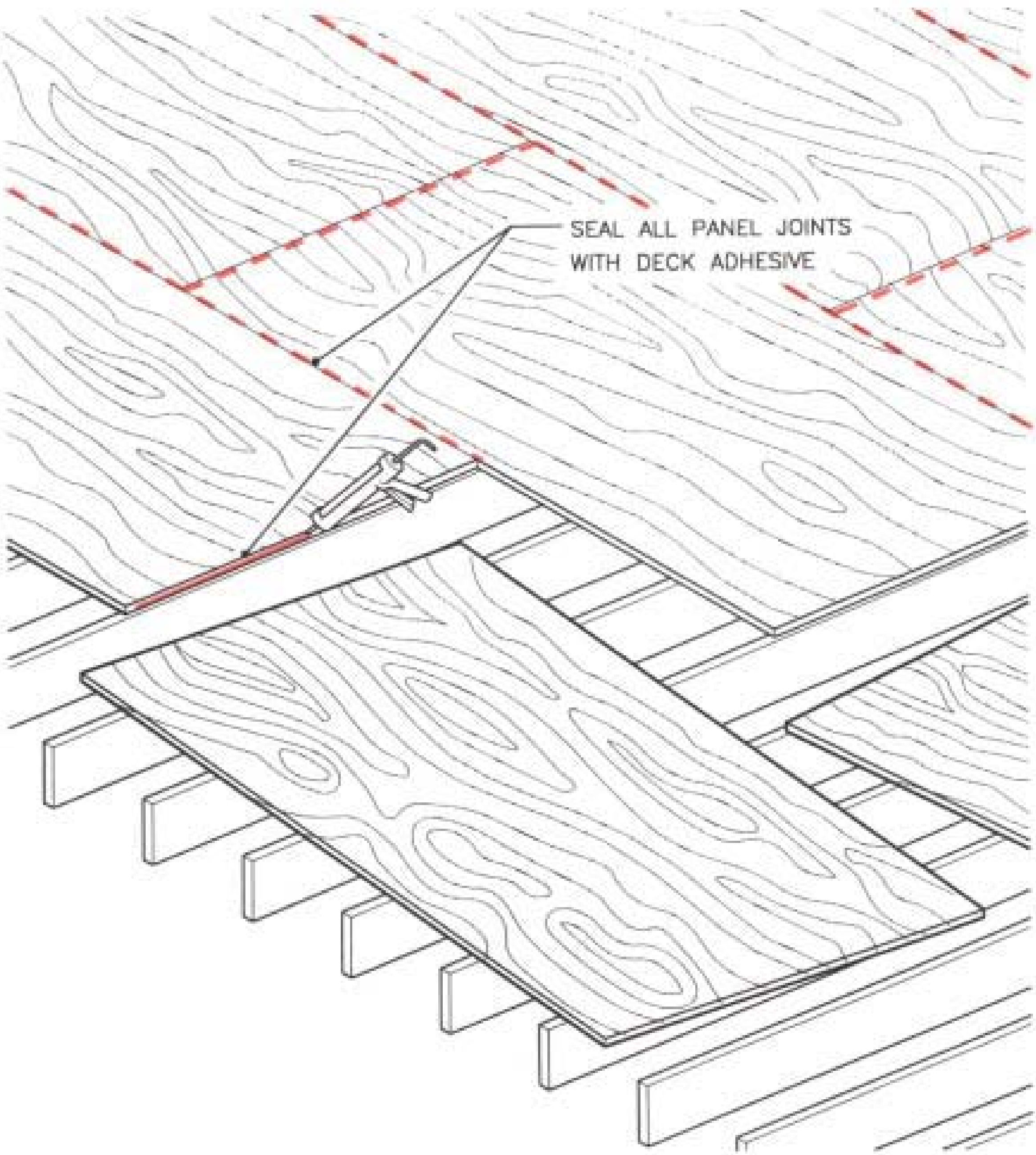


Figure 9N
POST AND BEAM DECKING FLOOR AIR BARRIER

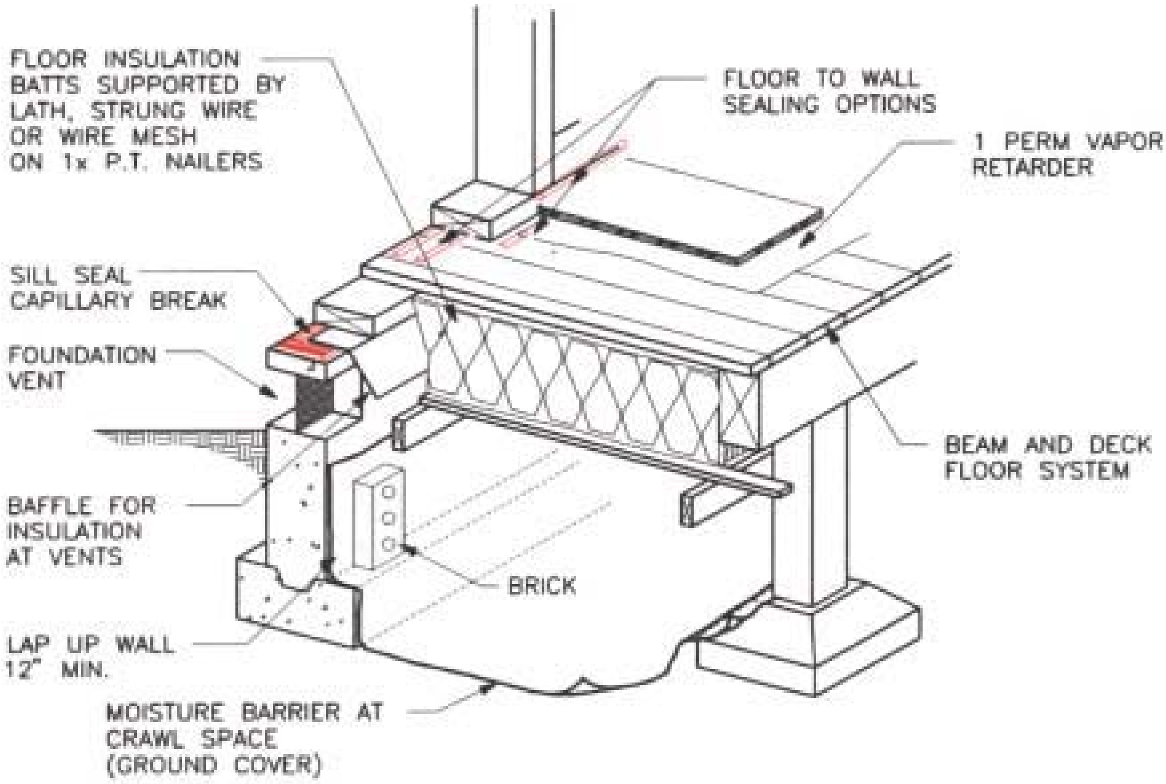


Figure 9O
BASEMENT RIM AIR BARRIER

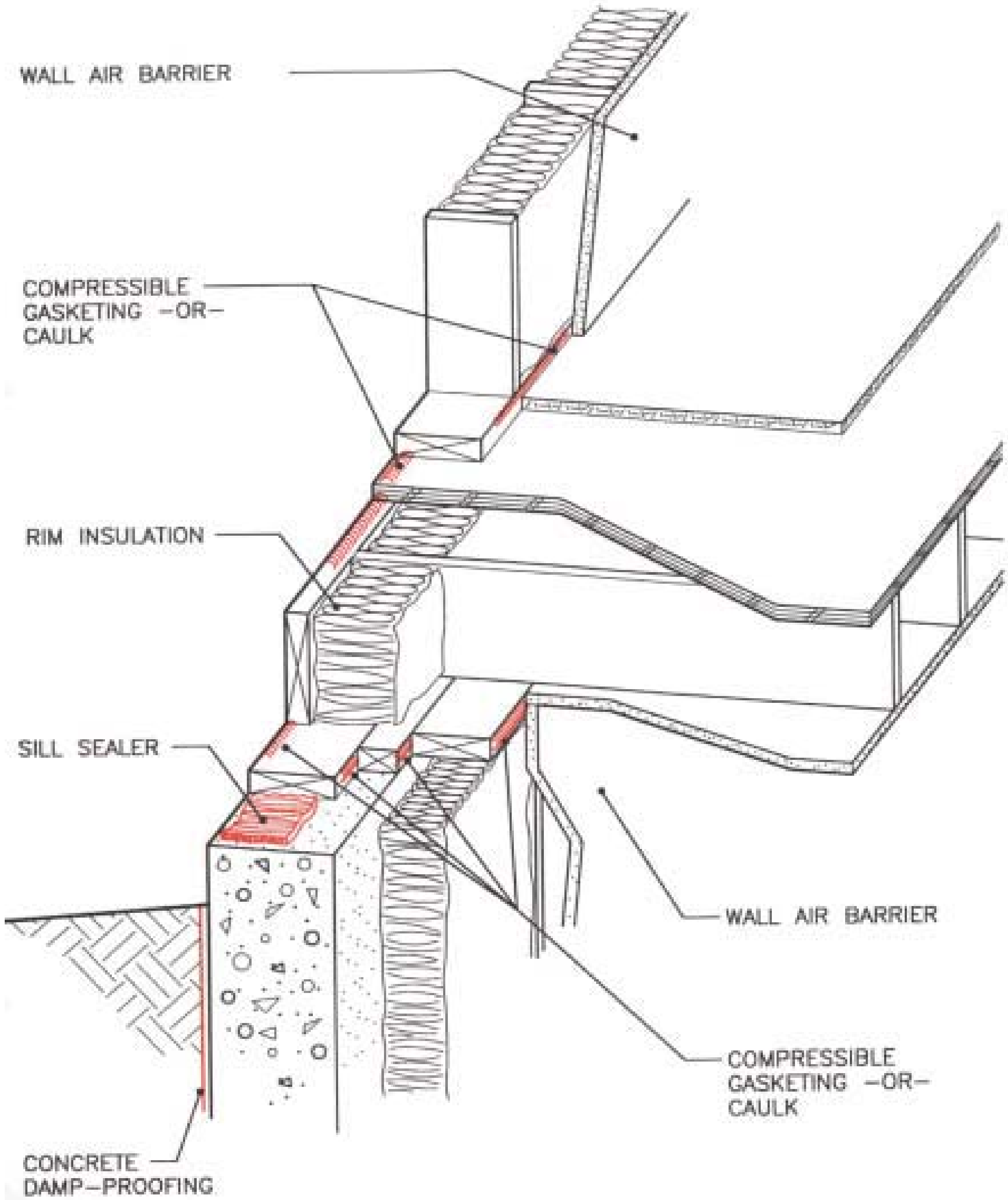


Figure 9P
RIM JOIST AIR BARRIER

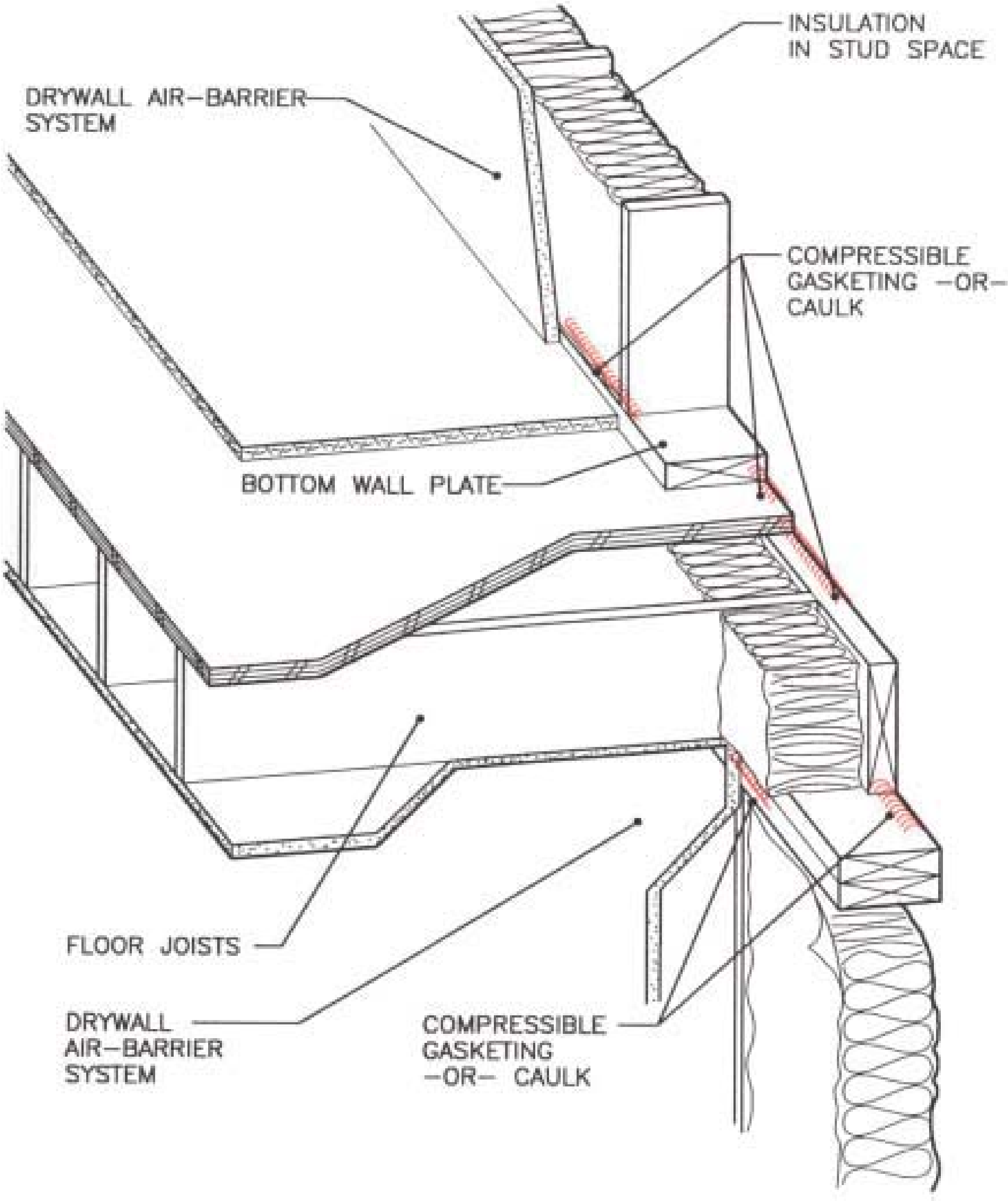


Figure 9Q
OPEN BEAM CEILING AIR BARRIER

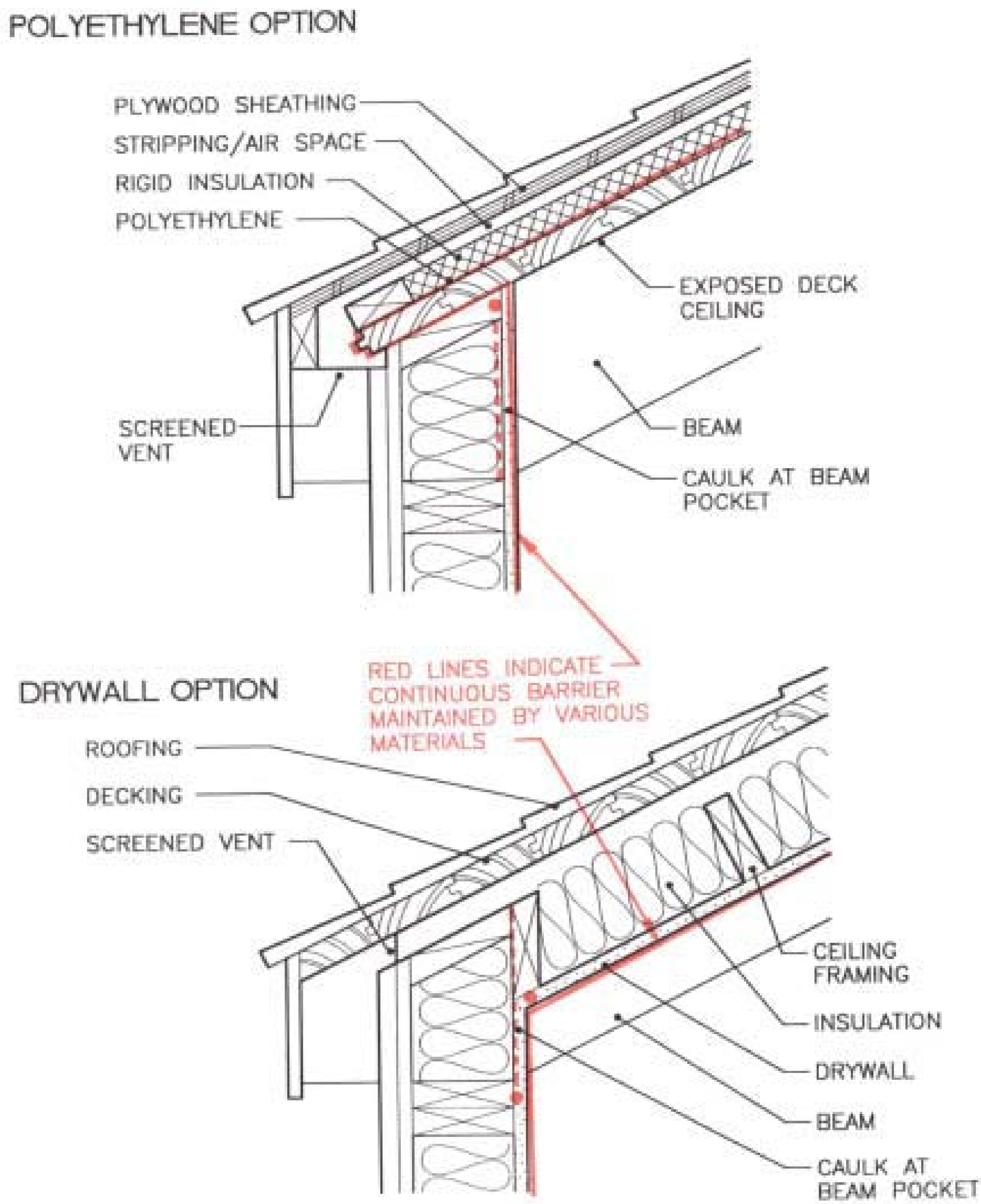


Figure 9R
WINDOW AIR BARRIER CONNECTION

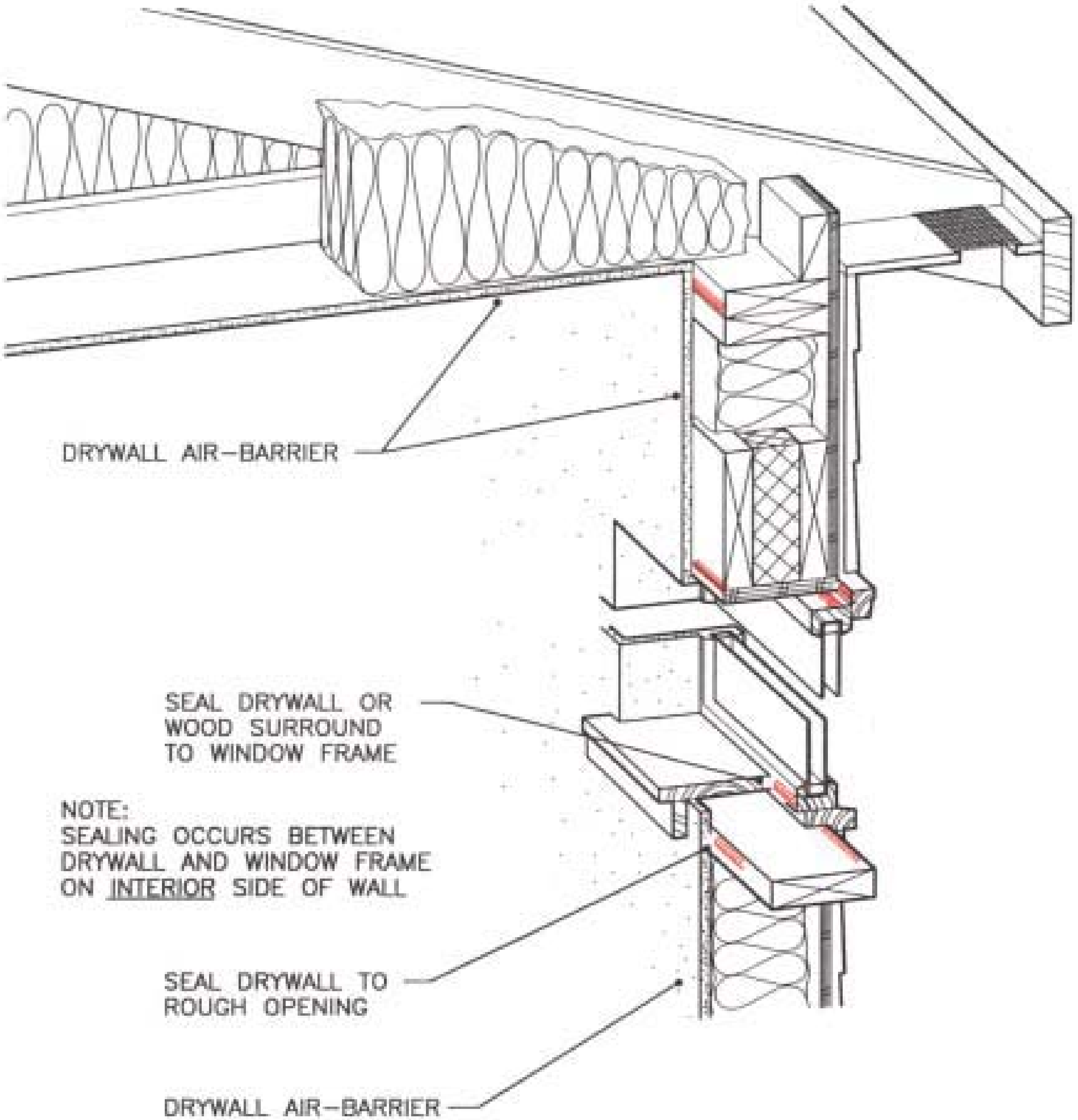
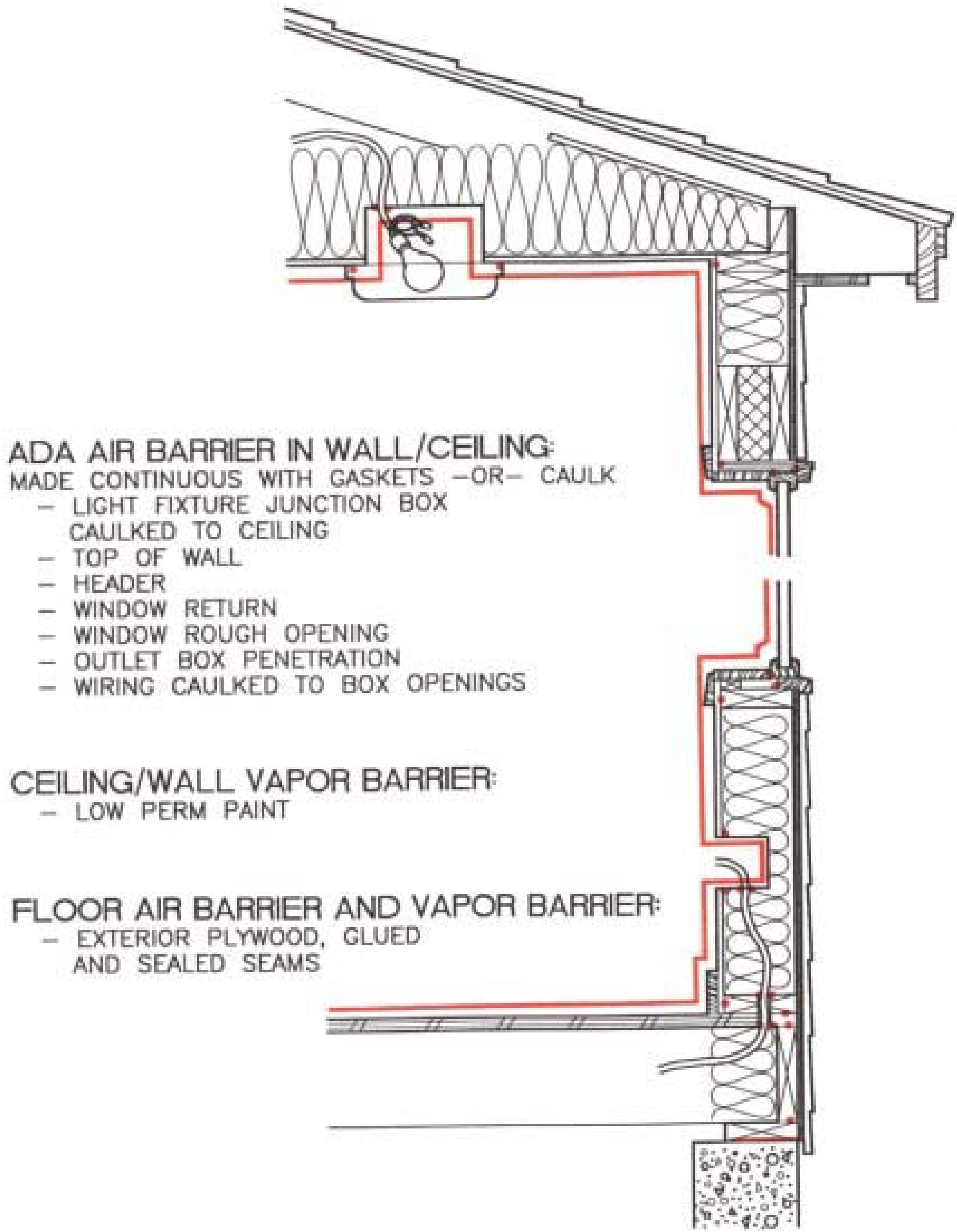


Figure 9S
CEILING/WALL/FLOOR AIR BARRIER CONNECTIONS



Chapter 10

Insulation Contractor

The insulation contractor is affected more than any other subcontractor by energy efficient construction practices. Because energy efficient homes are better insulated, the insulation contractor sells more product. The wide variety of approaches to Super Good Cents construction requires a wide variety of insulation strategies and products.

It is safe to assume that R-values for Super Good Cents homes are higher than most state codes, but often you do not know actual R-values until the Super Good Cents utility representative reviews the house plan. In many cases, R-values in one component are boosted to compensate for lower performance of other components.

Bidding the job before plan review may lead to unpleasant surprises. To avoid surprises and re-figuring bids, make sure the general contractor has had the plans reviewed and that the utility has approved R-values shown on the plans.

Super Good Cents utility representatives look at the quality of installation. Train employees in correct application. Make sure your bids include time to do thorough and careful insulating.

FLOOR INSULATION

Floor insulation levels vary from house to house. Underfloor insulation is typically R-30 to R-38.

How the Floor Framing System Affects the Insulation Contractor

Post and beam floors using 4x6 beams do not easily accommodate R-30 and higher insulation. Since typical R-30 insulation is 9-1/2 inches deep, these floors are too shallow to allow full insulation loft. You need an additional suspension system. See Figure 10B.

The trick is to get a suspension system that does not compress insulation. Compressing insulation is like throwing away part of the purchased R-value during installation.

In some cases, the designer or general contractor simply has not thought about the new conservation measures. Mention potential conflicts between floor framing cavities and required insulation. 4x8 beams and 2x8 joists accommodate high density R-30 insulation. See Figure 10C. Many builders find deeper floor framing less expensive. (Spans can be longer so fewer rows of posts and beams are needed.)

Figure 10A
JOISTED FLOOR INSULATION

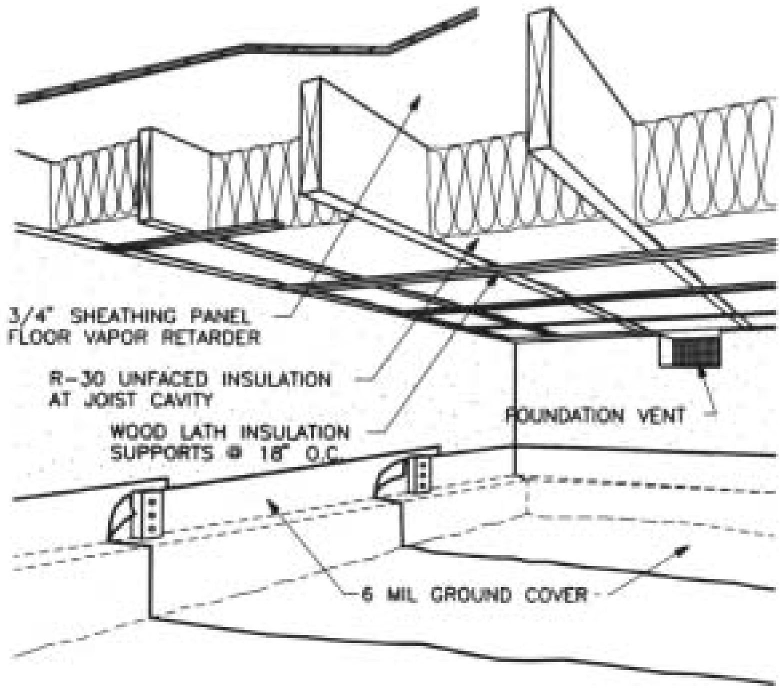


Figure 10B
POST AND BEAM FLOOR WITH SUSPENDED INSULATION SUPPORTS

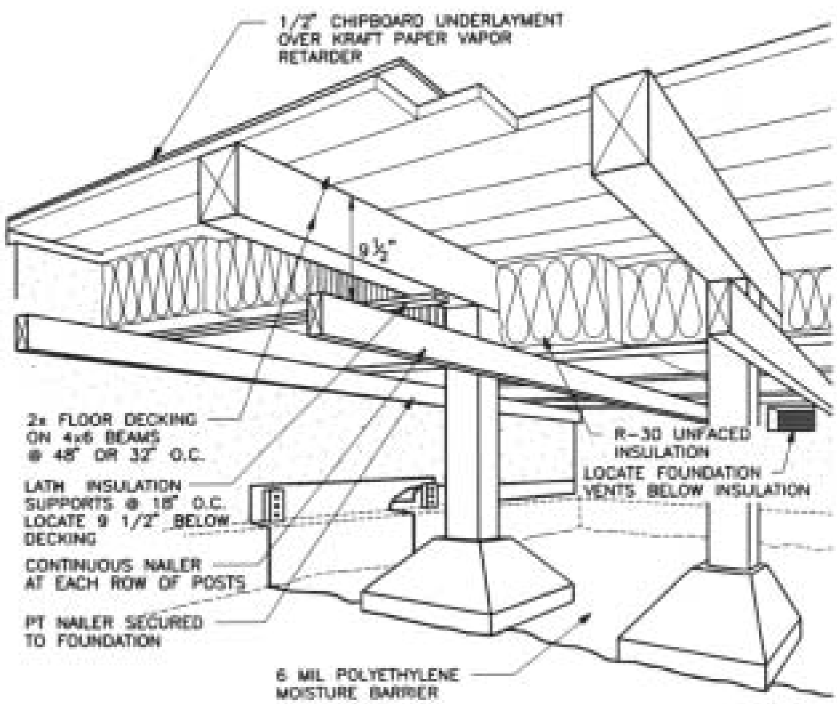
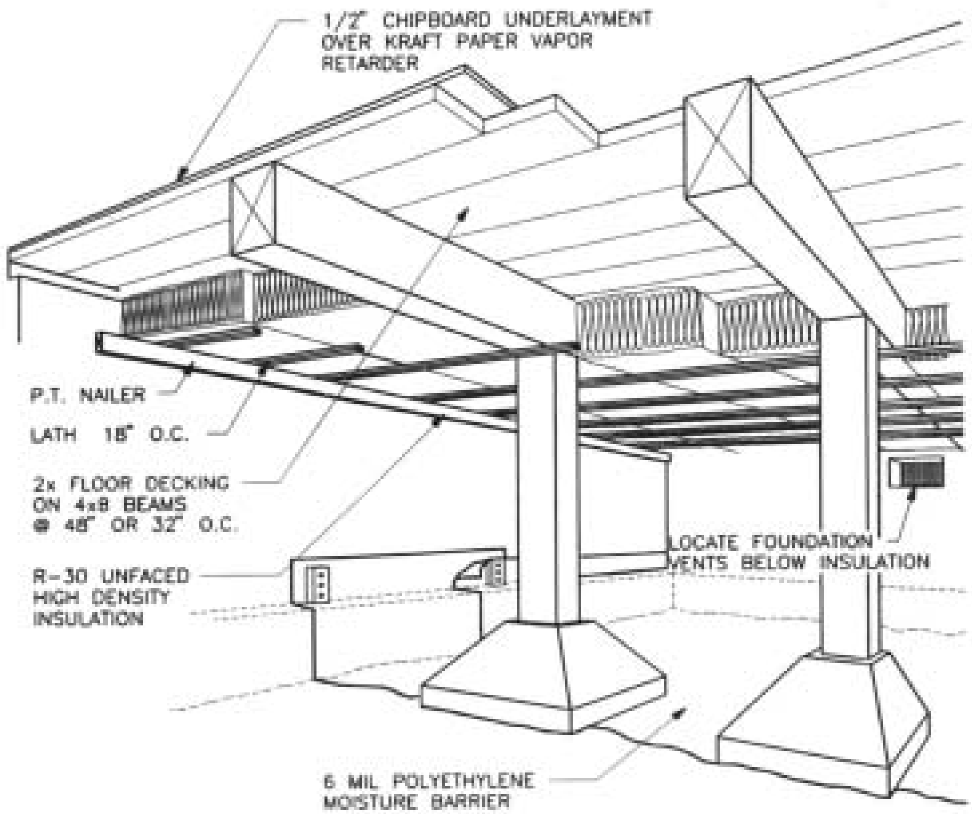


Figure 10C
POST AND BEAM FLOOR WITH HIGH DENSITY INSULATION



If floor framing cannot be changed to accommodate Super Good Cents insulation, be sure your bid includes the cost of a suspension system.

I-beam floors require special “full width” batts. Standard width batts are not wide enough. They leave gaps at each side of the joist cavity that reduce the effectiveness of the insulation system.

Vapor Retarder

A 1-perm vapor retarder on the warm side of the floor insulation is a requirement of most building codes as well as the Super Good Cents program. The vapor retarder keeps indoor moisture from diffusing into floor cavities.

Some floor framing systems have built-in vapor retarders that prevent moisture diffusion through the floor. Three-quarter-inch plywood floors and three-quarter-inch wafer board are examples of sheathing products that qualify as vapor retarders. They have a perm rating of 1 or lower. You do not need faced batts with these floor framing systems.

2x floor decking, on the other hand, is not a vapor retarder. To meet vapor retarder requirements, place asphalted kraft paper or other appropriate material above the decking.

Half-inch chipboard subfloor is not a vapor retarder either. If asphalted kraft paper is not shown on the plans, use kraft or foil faced batts to meet floor vapor retarder requirements.

Adequate Support

Install floor insulation up against the floor, but do not let the suspension system compress it. Do not let insulation sag away from the floor. Make sure the suspension system supports batts evenly.

Ground Cover

A 6-mil polyethylene black ground cover is a requirement of most building codes as well as the Super Good Cents program. The cover prevents ground moisture from dampening floor insulation. The ground cover does not replace the 1-perm floor vapor retarder. They are separate moisture protection requirements.

Cover the entire area under the floor with the ground cover. Lap the cover at all seams. Local building codes may have more stringent requirements for crawl space ground covers. Check with your local building department.

Crawl Space Ventilation

There is not much the insulation contractor can do if the concrete subcontractor does not supply adequate crawl space venting. Most building codes as well as the

Super Good Cents program require venting to help keep the insulation and crawl space dry. Venting reduces potential growth of mold and mildew and structural damage to the floor. It also helps protect indoor air quality.

Super Good Cents specifications call for 1ft^2 net free vent area per 150 ft^2 of floor area. In some locales the minimum is 1 ft^2 net free vent area per 300 ft^2 of floor area. Check with the local code official for local requirements.

If a home is in an area with radon problems, local building code may require crawl space vents as a protection measure. Verify that the vents are adequate. Let the general contractor know if they are not.

Net free vent area typically is stamped on the side of the vent. If you do not see a stamp, assume that the net free vent area is approximately half the vent surface area. See Chapter 3 for more details on crawl space ventilation.

Floor insulation should not block vents or funnel outside air into or above insulation.

Protect Plumbing From Freezing

The thick layer of insulation in the floor makes the living area warmer and crawl space area colder in winter. Protect pipes from freezing. Three-quarter-inch black pipe insulation or heat tape are commonly used. Heat tape fails during power outages. See Figure l0D.

If you get the chance to make recommendations before the plumber begins work, suggest to the general contractor that plumbing be run just below the subfloor. Floor insulation can be installed below plumbing. That is the best way to prevent pipe freeze-ups.

WALL INSULATION

Wall cavity insulation values in Super Good Cents homes usually are at least R-21. Insulating sheathing often is installed on the exterior (Figure 10E shows above grade wall details) or interior of walls to raise total R-value to R-26 or even higher. See Chapter 9 for details on interior sheathing systems. Interior insulating sheathing could be installed by a number of different trades, including insulation contractors.

Many Super Good Cents homes have 24-inch on center framing in the walls. This may not show on the plans you use to make your bid. Ask the general contractor about frame spacing.

Remember, R-26 wall standards affect skylight wells, vault end walls, pony walls, stairwells, and any other wall that separates heated from unheated space.

Figure 10D
PIPE INSULATION

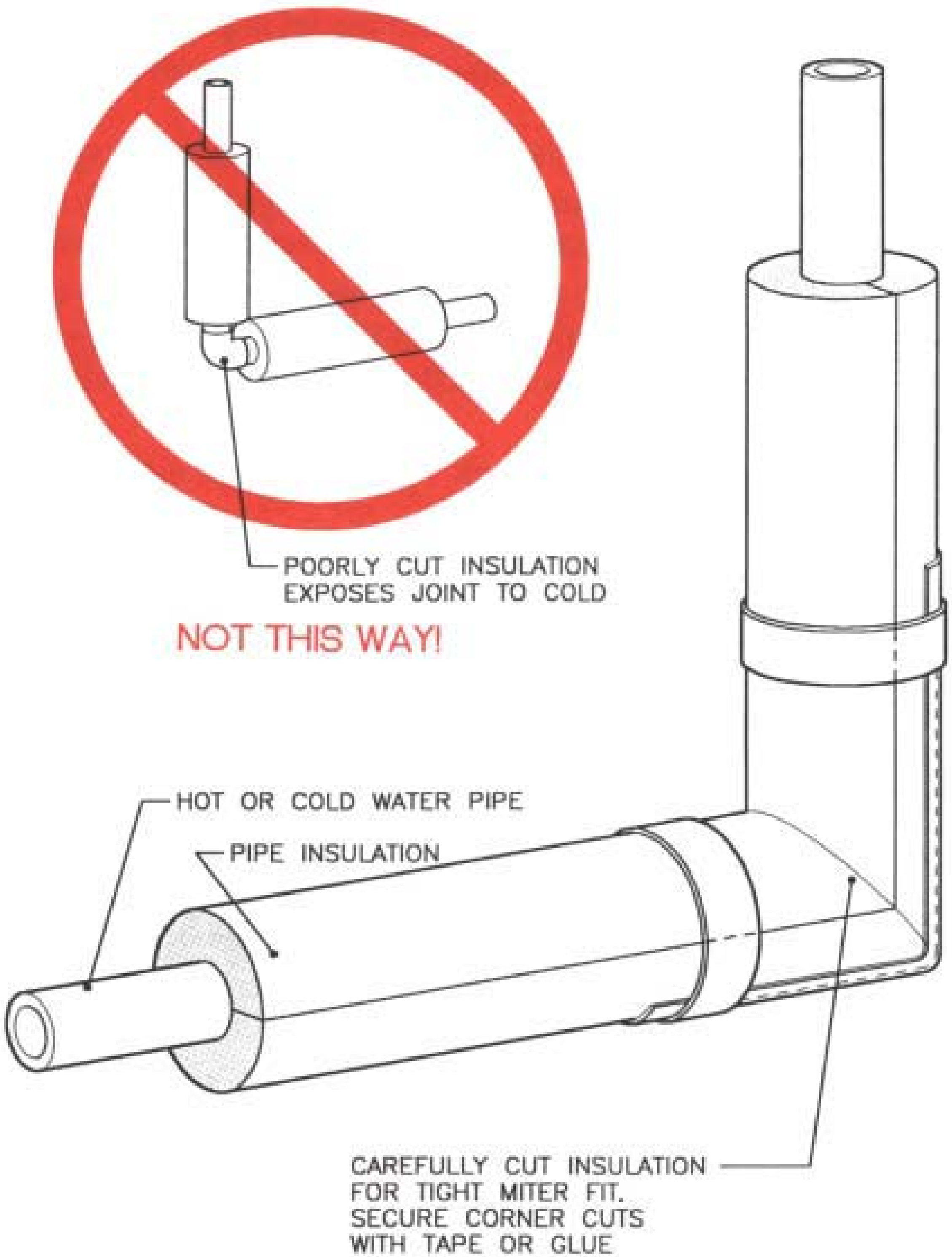
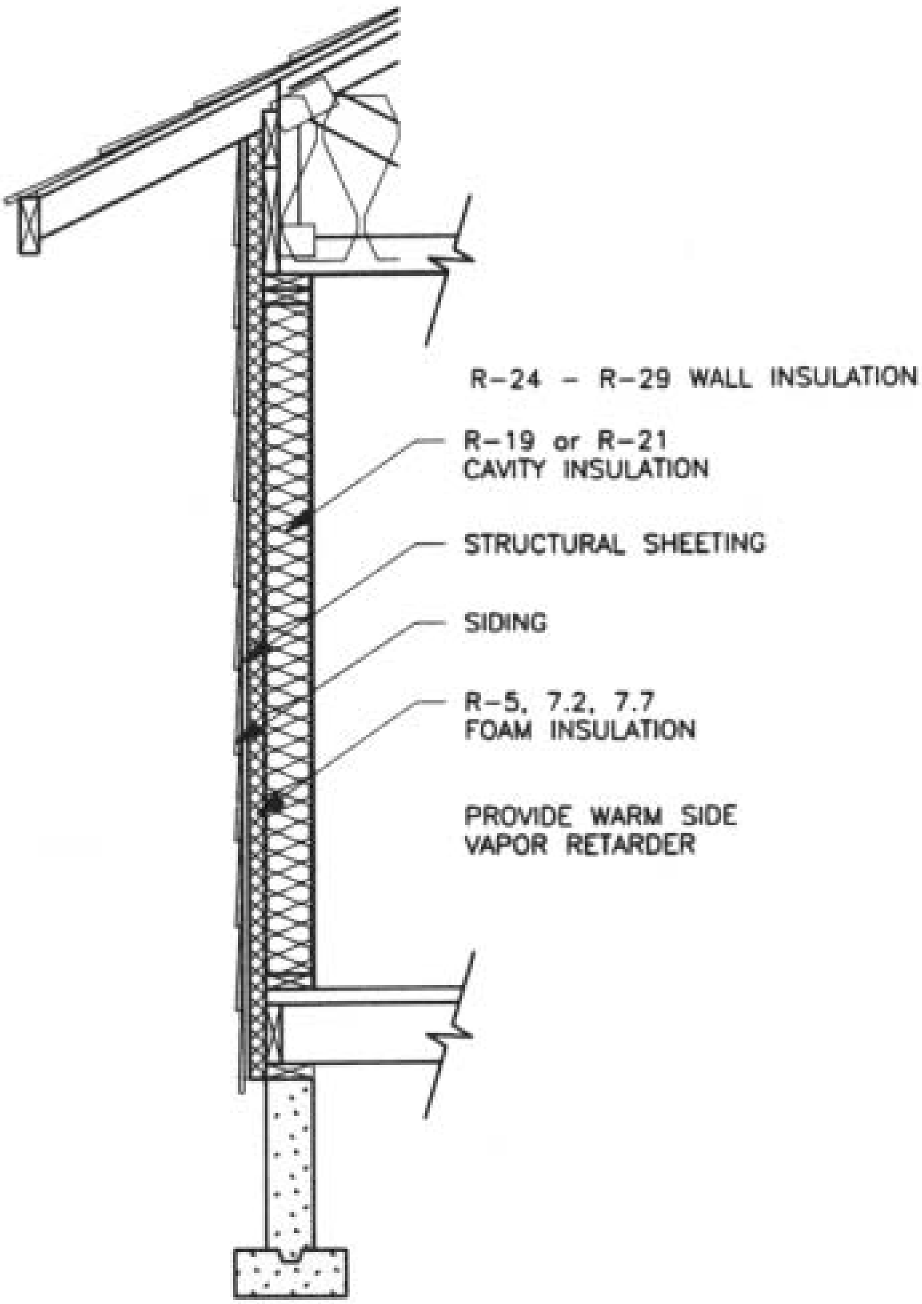


Figure 10E
ABOVE GRADE WALL WITH EXTERIOR RIGID INSULATION



Quality Work

The house is going to pass or fail based on quality of the insulation job. Do not cut wall insulation short or long. Cut it to fit the cavity. Do not cram insulation into the cavity. Place it in the cavity and fluff to its full loft.

Cut batts around switch and outlet boxes to minimize compression. See Figure 10F. Split batts around plumbing and wiring.

Vapor Retarders

Like most building codes, the Super Good Cents program requires a 1-perm vapor retarder on the warm side of wall insulation. Faced batts are a common way to meet this requirement.

Faced batts perform better if flanges are face-stapled rather than inset-stapled. See Figure 10G. Face stapling avoids compression of insulation.

Face stapling must be smooth. Carefully set staples, or you will make the drywall contractor's job more difficult. Finish the job by stapling facing to the top and bottom plates.

If you use unfaced batts instead, you must install a separate vapor retarder. One method is to use 4- to 6-mil polyethylene, lapped 3 inches where separate sheets meet, and stapled to the top and bottom plates.

Another popular vapor retarder is vapor retarder paint on the drywall. You may be able to make a more competitive bid if you shift the vapor retarder responsibility to the painter.

Since the vapor retarder strategy varies, ask the general contractor who is supplying the vapor retarder.

Unusual Walls

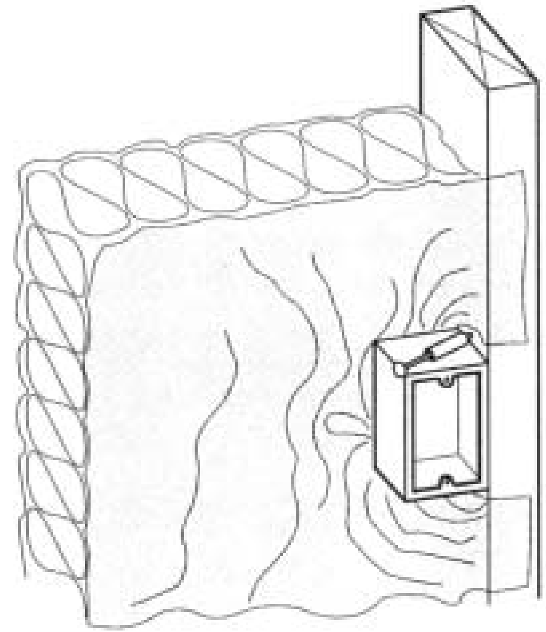
You may occasionally run into walls with features you have not seen before. Figures 10H and 10I show construction details for double walls and strap walls that call for two or three layers of batt insulation or extra thick blown insulation.

Strap walls may require high density insulation in the strapped cavity to achieve the R-values called for in the plans. Your supplier may have high density insulation on hand for commercial construction customers. When you see double walls or strap walls, check with the general contractor to find out what R-value to use in each framing cavity.

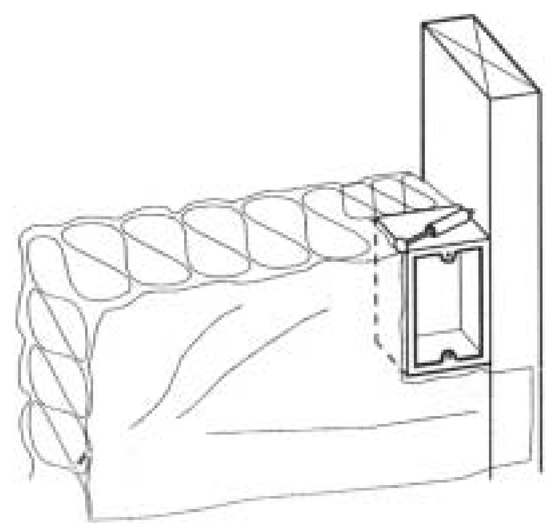
Air Sealing and Air Barriers

Air sealing and air barriers are new concepts in construction. Chapter 9, "Air Tightening Specialist," describes several air sealing and air barrier techniques.

Figure 10F
INSULATION CUT-OUT AT SWITCH BOX



WRONG!
INSULATION IS SMASHED BEHIND THE JUNCTION BOX



CORRECT
INSULATION CAREFULLY CUT TO FIT BEHIND JUNCTION BOX AND SNUGLY AT SIDES

Figure 10G
FACE STAPLING

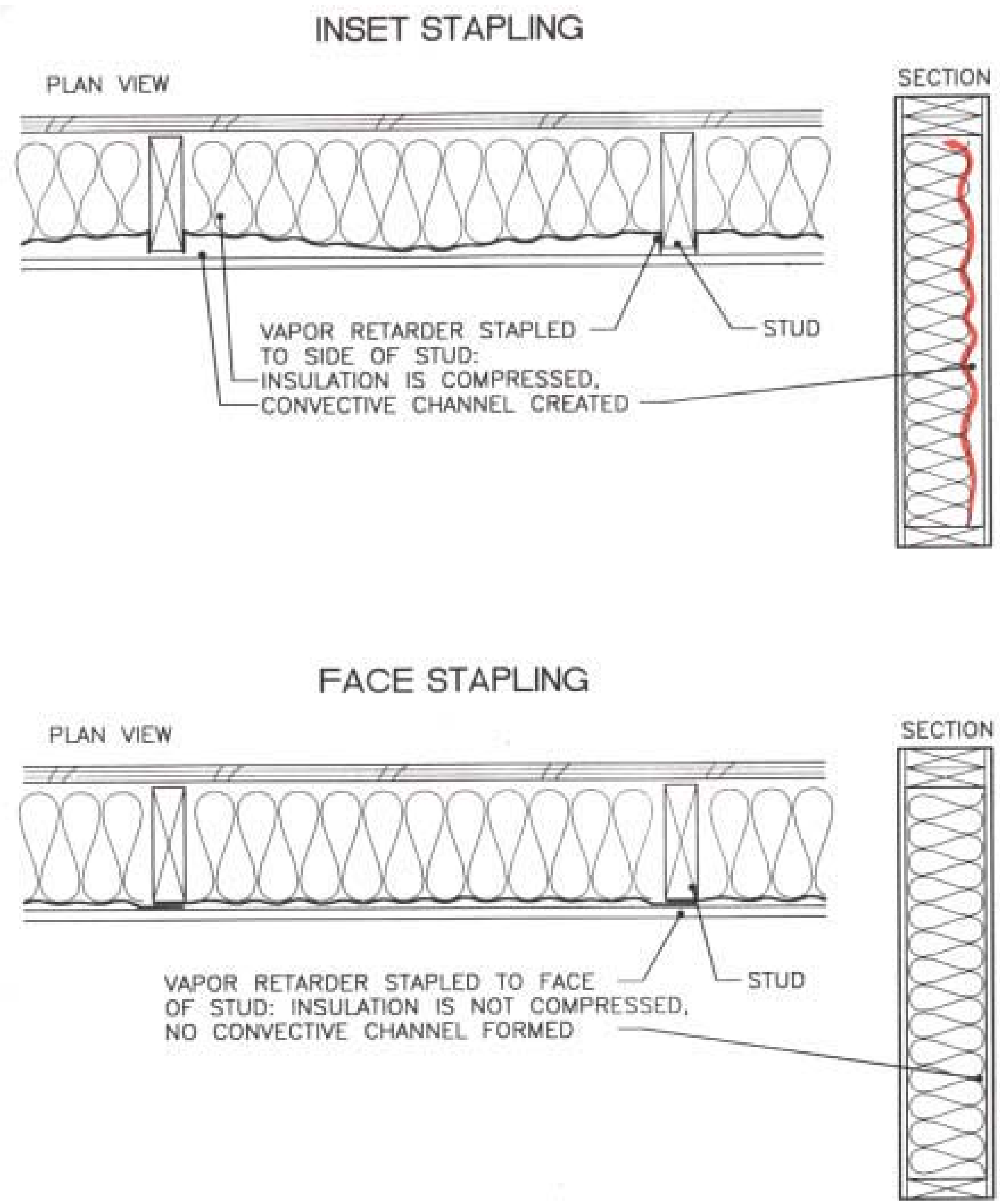


Figure 10H
DOUBLE WALL

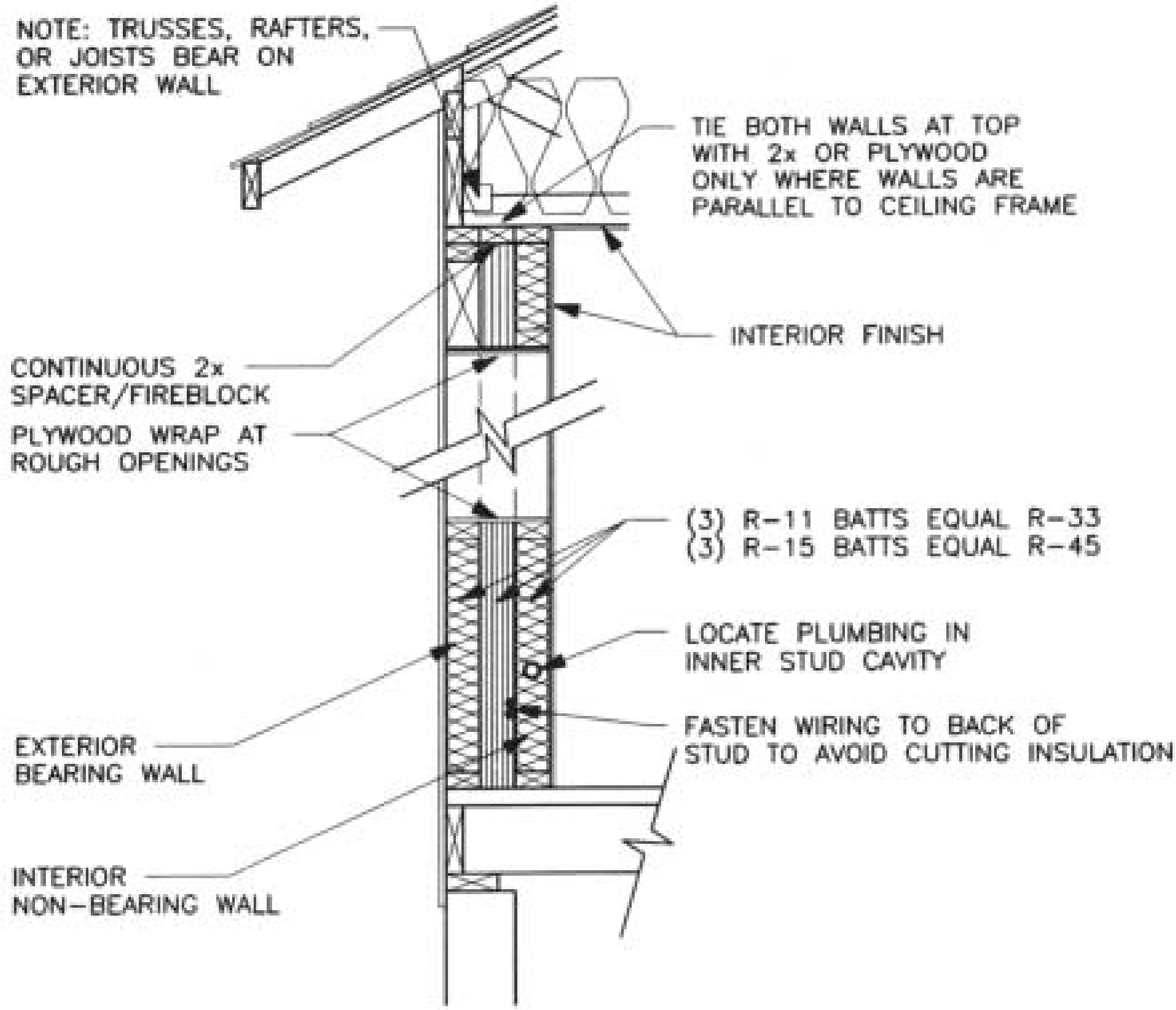
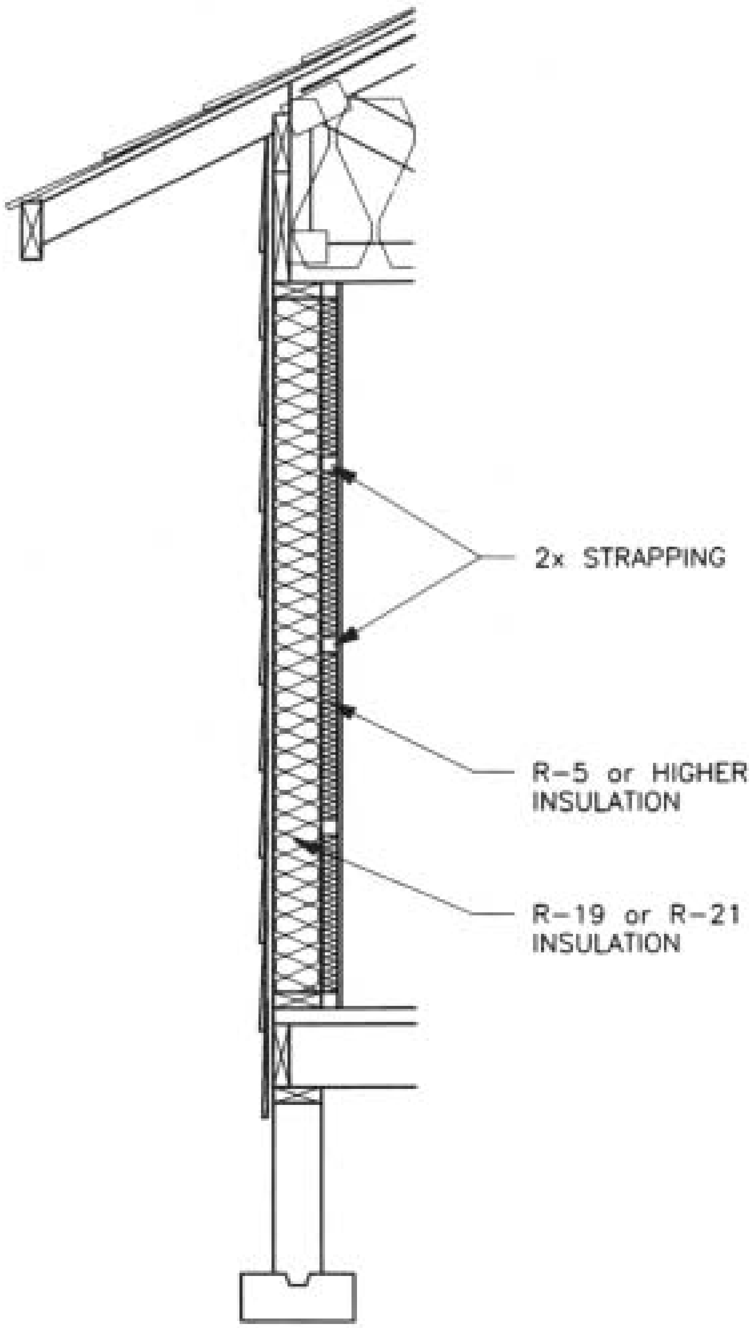


Figure 10I
STRAP WALL



Air sealing is a key component in energy performance of Super Good Cents homes. Someone is going to do it and get paid for doing it well. The insulation contractor is well-positioned to do the air sealing work and become the air tightening specialist on the construction team. Look into the work described in the "Air Tightening Specialist" chapter and consider expanding your insulation business.

ATTIC INSULATION

Attic or flat ceiling insulation in Super Good Cents homes is typically R-49. Many attics incorporate "Advanced Ceiling Framing," designed to get full R-49 over all exterior walls. In some cases, ceiling insulation may be beefed up to R-60 to compensate for lower thermal levels in other components.

Correct Application

Utility representatives and code officials look in the attic for the insulation certificate and bag label to verify correct insulation densities. Densities also may be spot-checked.

Fire Clearances

Preparing for the insulation job includes baffling flues and other electrical and mechanical components that are not rated for insulation cover.

NFPA-54, the National Fuel Gas Code, gives clearances for gas flues. Clearances for oil fired components are listed in NFPA-31, Standard for the Installation of Oil Burning Equipment. Masonry standards are given in NFPA-211, Standard for Chimneys, Fireplaces, and Vents. Order from the National Fire Protection Association, P.O. Box 9101, Quincy, MA 02269-9101;1-800-344-3555. Chapter 37 of the Uniform Building Code also addresses clearances for combustible materials.

Recessed lights in insulated spaces such as attics must be IC (insulation cover) rated if they are to be covered with insulation. If you find a non-IC rated fixture, let the general contractor know right away that you cannot cover it until it is replaced with an IC rated fixture.

Fire clearances required for non-IC rated lights leave big holes in the thermal envelope of the house. Super Good Cents utilities will not certify the house unless IC fixtures are installed.

Attic Hatch

Baffles are needed at the attic hatch to keep attic insulation from falling into the home. Some contractors use batts to form the baffle. They are easy to use and provide ceiling insulation as well. If the hatch is in the heated ceiling area, insulate it to at least R-38. Use balls or rigid foam board.

Advanced Frame Ceilings

Typical Super Good Cents homes use "advanced framing" to improve the R-value of ceilings. Advanced framing provides enough height near the eaves to get at least R-38 all the way out to the area above exterior walls. Chapter 4 has illustrations of advanced frame ceilings.

Advanced framing changes the amount of insulation you use. The added height lets you install more insulation.

TIP: In some cases, the builder does not leave enough height for full R-38 blown-in insulation. To achieve R-38, use a material with more R-value per inch. For example, typical blown-in fiberglass requires about 15 inches for R-38. High density batts provide R-38 in about 10 inches. You can use batts near the eaves and blow the rest of the attic. Where local building codes allow, batts can replace vent baffles too, saving on the cost of installing separate baffles. Or you can make your own baffles using high R-value foam insulation. Make sure the foam has a flame spread rating of 25 or lower.

Ventilation in Attics

Most building codes, as well as the Super Good Cents program, require attics to be vented. You may not be responsible for providing vents, but if the vents are not there, let the general contractor hear about it.

If about half the vent area is low at the soffit, and half is high near the ridge, you should see 1 ft^2 net free area of vent per 300 ft^2 of ceiling. When all vents are on the same level (gable end vents), the venting requirement is 1 ft^2 net free vent area per 150 ft^2 of ceiling area.

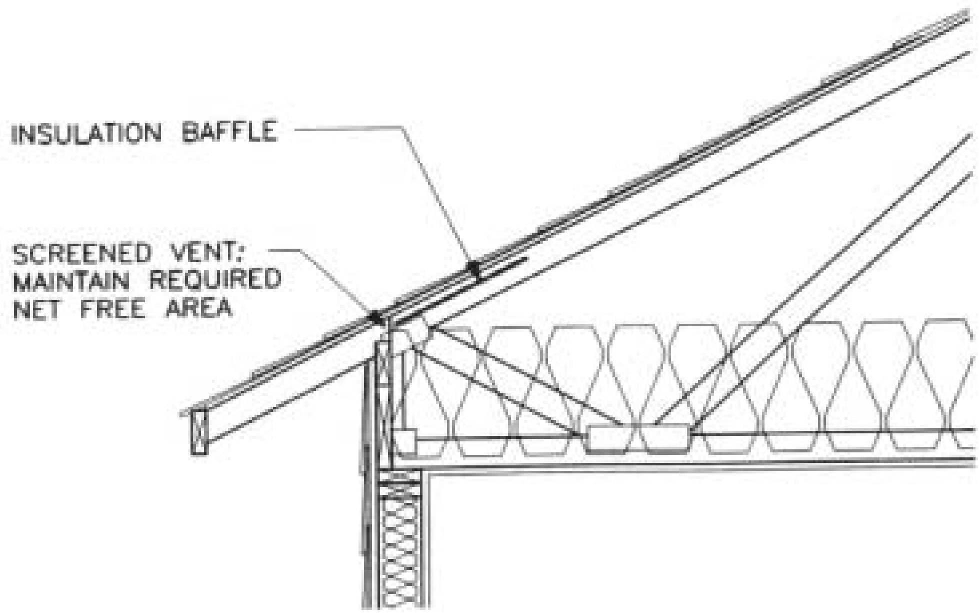
If the home has soffit or eave vents, make sure they are baffled to prevent blown-in insulation from blocking the flow of ventilation air. See Figure 10J. Vent baffles usually are installed by the framing contractor.

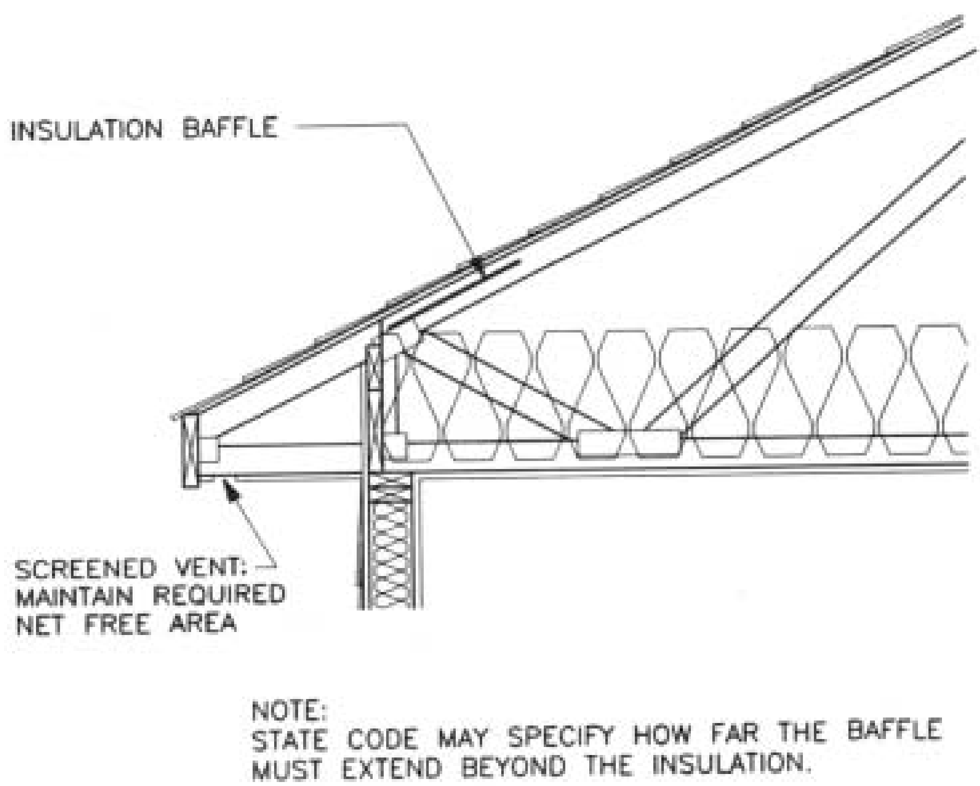
Vapor Retarders in Ceilings With Attics Above Them

1994 LTSGC 4.1.1

Most building codes do not require vapor retarders in ceilings below attic spaces. The Super Good Cents program, however, requires 1-perm vapor retarders in these ceilings.

Figure 10J
METHOD FOR BAFFLING AT EAVES





The insulation contractor often installs a polyethylene vapor retarder in the ceiling when installing wall insulation. You also can meet the vapor retarder requirement by installing faced ceiling batts. Since blow-in technology is quicker and cheaper than faced batts, faced batts are rarely used in attics.

Vapor retarder paint is another option for ceiling moisture protection.

IMPORTANT: Taping and texturing releases a lot of moisture in the home. Painting adds to the moisture buildup. Propane and oil-fired heaters are often used to dry tape and texture, but these combustion heaters produce a lot of moisture themselves. If you use polyethylene as the ceiling vapor retarder, insulate the ceiling immediately after the ceiling drywall is hung (and before taping and texturing). If the ceiling is not insulated immediately, the poly vapor retarder will be cold. In cold weather, moisture released inside the building during taping, texturing, and painting may reach its dew point at the cold vapor retarder and cause extensive moisture damage to the ceiling.

Do not lose a ceiling. If you use poly as a vapor retarder, schedule the ceiling insulation immediately after the ceiling drywall is hung. Encourage the drywall contractor and the general contractor to ventilate the building to get the moisture out.

VAULTED CEILING INSULATION

Super Good Cents vault insulation is R-38. This requires at least 12x rafters to leave an air space for ventilation above the insulation. Many scissor truss vaults, deep cavity flat truss vaults, and I-beam vaults are deep enough to easily accommodate R-38 insulation.

Open beam and deck vaults present the biggest challenge.

Vault Ventilation

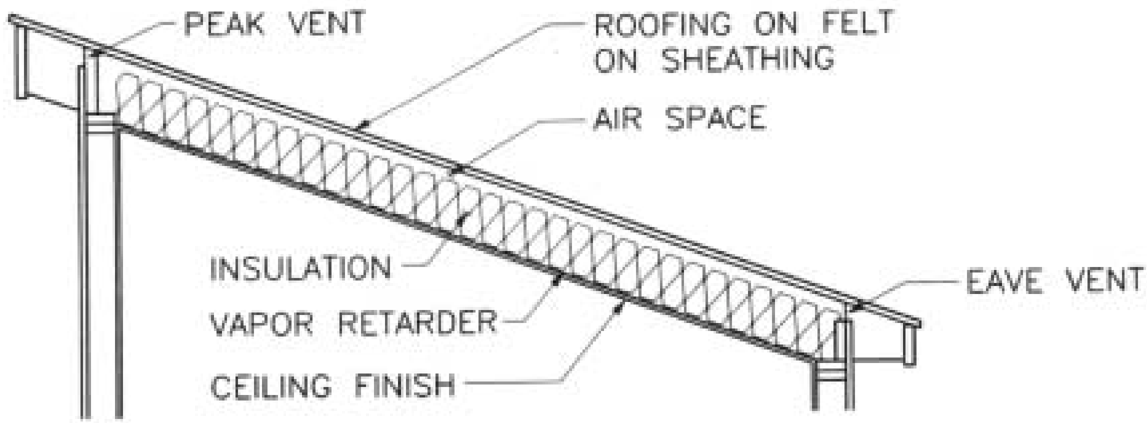
Vault ventilation is a controversial subject. The Super Good Cents program requires ventilation in all ceilings, including vaults. In some parts of the region, however, ventilation has been blamed for causing moisture problems in vaults. Local practice may allow closed cavity (unventilated) vaults. If there is a conflict between Super Good Cents ventilation specifications and local building code requirements, the building code takes precedence.

Figure 10K shows ventilated and closed cavity vaults.

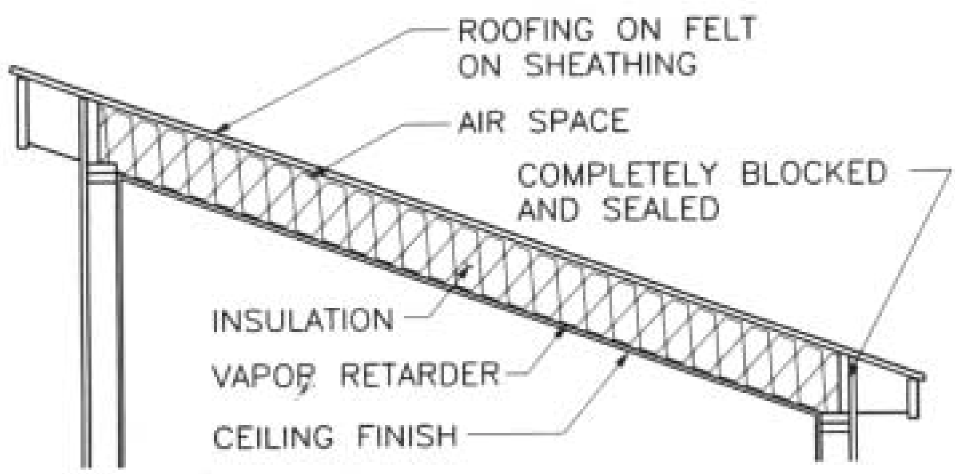
Most vault moisture comes from indoor air. The most important thing you can do to keep vault cavities dry is to thoroughly seal ceiling air leakage paths and install a vapor retarder on the warm side of the insulation.

Figure 10K
VENTILATED AND CLOSED CAVITY VAULTS

VENTILATED VAULT



CLOSED VAULT



The theory behind ventilating vaults is that any moisture that gets around the vapor retarder can be moved outside. Ventilation also helps avoid excessive heat buildup in vaulted ceilings in summer. Excessive heat can prematurely age composition roofing products. Some manufacturers of composition roofing void their warranties if their products are installed over unventilated areas. Excessive heat buildup also increases air conditioning costs.

Ventilation is easy in scissor truss vaults, deep cavity I-beam vaults, and flat truss vaults. There is plenty of room for insulation and plenty of air space left over to accommodate airflows through vault cavities. The trick is to provide air vents at both ends of the vault, so that air entering at one end can get out at the other end.

Screened vents at the wall or soffit are common. They let air into the cavity.

Continuous ridge and continuous vault vent products are less well known. They let air out all along the top of the vault. Individual roof jacks do not allow cross cavity ventilation. Holes drilled through rafters to facilitate cross cavity ventilation do not work well. Separate roof jacks for each cavity usually are visually unacceptable. Continuous ridge vents solve these problems and are visually unobtrusive.

The insulation contractor is caught in the middle. You need ventilation to protect insulation, but you are dependent on the designer to specify appropriate ventilation and on the framing contractor to cut in the vents. Insulation contractors are understandably wary of this issue, because they have been blamed for moisture problems in vaults.

The idea behind closed cavity vaults is that if you pack the vault full of insulation and do not let moisture-laden air in (from indoors or outdoors), you will not have a moisture problem. Whether this approach is successful depends on the effectiveness of ceiling air leakage control and the vapor retarder.

Vault Vapor Retarders and Air Sealing

Many building codes require a 0.5 perm vapor retarder in vaulted ceilings. This is a more stringent requirement than the Super Good Cents program's 1.0 perm requirement. If local code calls for a 0.5 perm vault vapor retarder, follow the code. Four to six mil polyethylene or foil faced batts usually meet the 0.5 perm vapor retarder requirement. Paint-on vapor retarders require more than one coat in most cases. See Chapter 12.

The vapor retarder will not prevent moisture problems if wiring, lighting, and other penetrations into the vault are not sealed. Air leakage through ceiling penetrations is a much more significant source of moisture in vaults than vapor diffusion, which is what the vapor retarder addresses.

One easily missed air leak into vaults is at partition wall intersections. Seal the drywall to the top plate to prevent air inside the partition wall from leaking into the vault.

MISCELLANEOUS INSULATION APPLICATIONS

Skylight Wells

Skylights are popular in Northwest homes. Vertical walls below the skylight make up the "skylight well." These walls separate heated interior space from the unheated attic. They must be insulated to the same R-value as exterior walls. Vapor retarder requirements are the same as for exterior walls.

Below Grade Walls

1994 LTSGC 2.1.6

The Super Good Cents insulation requirement for below grade walls (in heated spaces) is R-21. Unless some part of the building structure is in the way, there is rarely a reason to use lower levels. Some building codes do not allow less than R-21 below grade under any circumstances.

Exterior insulation must extend from the top of the wall to the footing. Interior insulation usually is placed in 2x4 interior walls that are held in from the concrete to achieve the appropriate cavity depth. See Figure 10L.

Wall vapor retarder requirements also apply to below grade walls.

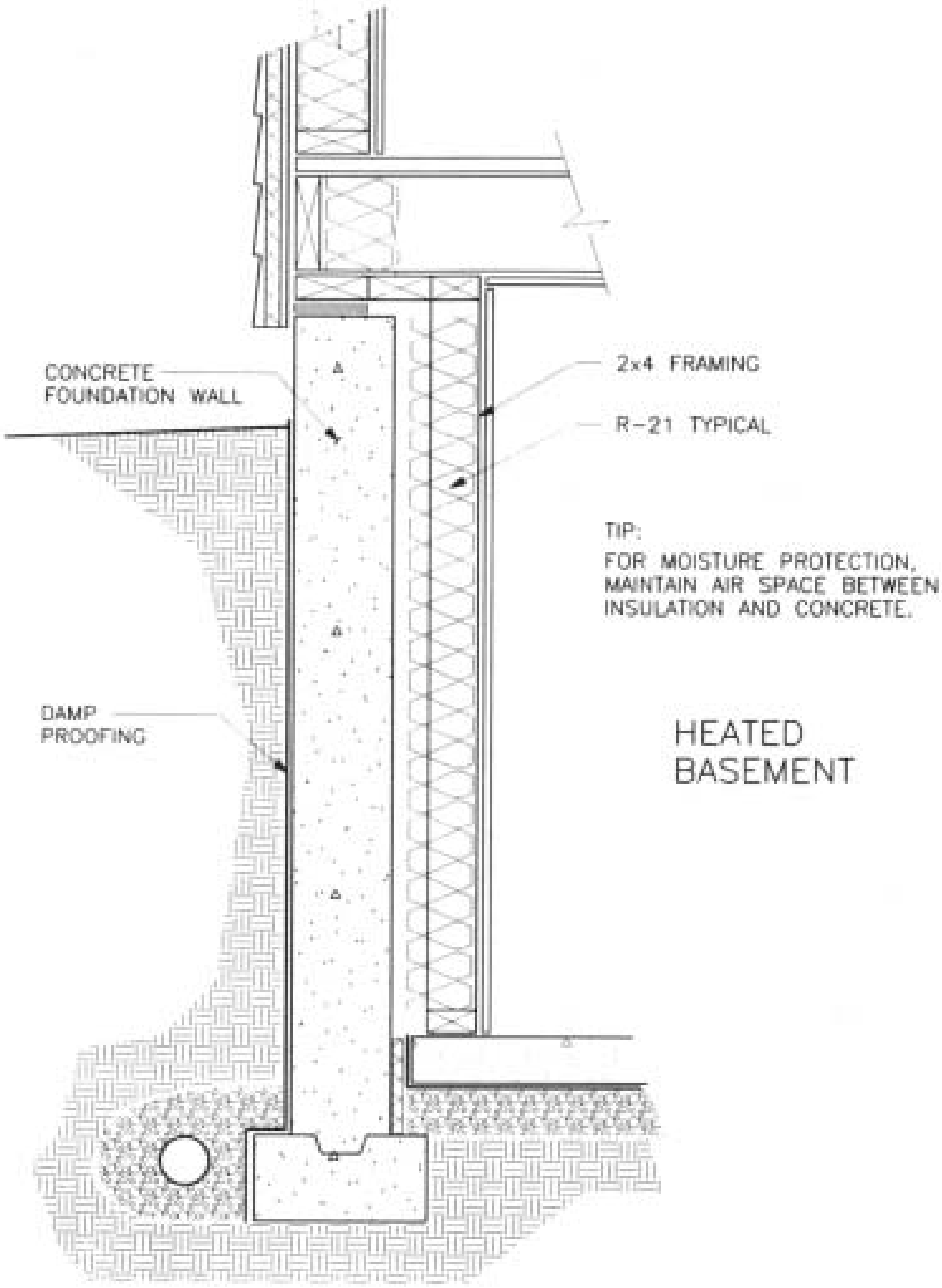
TIP: Because moisture can easily migrate through concrete, and because damp proofing may not be perfect, hold the interior framed wall in far enough so that installed insulation does not contact concrete.

Rim Joists

1994 LTSGC 2.1.7

Rim joists between heated floors of two-story homes and the rim over the mudsill in heated basements must be insulated to the wall R-value.

Figure 10L
BELOW GRADE INTERIOR WALL INSULATION



Chapter 11

Drywall Contractor

The Super Good Cents program does not affect the drywall contractor as much as it affects other trades. Still, several new energy-efficient construction techniques affect drywall installation.

FACE STAPLING INSULATION

In some Super Good Cents homes, faced insulation is stapled to the stud face rather than inset stapled to the sides of the studs. Face stapling compresses insulation less.

To avoid face stapling, you can use unfaced insulation in the wall and apply vapor retarder paint over the drywall. This approach avoids insulation compression and provides a clean stud surface for drywall.

POLYETHYLENE VAPOR RETARDERS

In many cases, polyethylene vapor retarders cover unfaced wall insulation. That prevents you from using adhesive. Take care to avoid ripping the vapor retarder.

Many Super Good Cents homes have polyethylene ceiling vapor retarders. Ceilings with polyethylene vapor retarders must be insulated immediately after ceiling drywall is hung and before taping and texturing begin.

Taping and texturing release a lot of moisture. If the ceiling is not insulated, the ceiling vapor retarder will be cold. Moist air cannot penetrate the vapor retarder and may reach its dew point in the ceiling drywall. That can mean extensive water damage to the ceiling.

When the ceiling drywall is hung (and before taping and texturing), call for ceiling insulation. If the ceiling is insulated, the vapor retarder will be warm, and moisture will not reach its dew point in the ceiling drywall.

GET RID OF MOISTURE

It is important to get rid of moisture produced during construction, including moisture produced during taping, texturing, and painting. Portable propane and oil-fired heaters release moisture during the combustion process. They are poor choices for drying energy efficient homes. Electric heaters and large capacity dehumidifiers remove moisture faster.

DRYWALL GASKETS

Drywall contractors may see foam or other gaskets stuck to wall framing. They are used in the "Advanced Drywall Approach" to air tightening. Gaskets seal drywall to framing and eliminate air leakage to the attic from interior and exterior wall cavities. Take care to avoid scraping gaskets off the framing. Removing gaskets increases air leakage from the house.

An alternative to gaskets is continuous beads of drywall adhesive. You need to apply the adhesive as you put up the drywall. If the general contractor plans to use this approach to Advanced Drywall air sealing, review the system together carefully so you can plan for additional time and materials.

If the house has an Advanced Drywall system, ask the general contractor who will provide gaskets or sealant. See Chapter 9 for Advanced Drywall Approach details.

INTERIOR RIGID FOAM

In some homes, interior rigid foam attached to the interior wall surface boosts overall wall R-value. Studs should be marked. Framers need to know that special drywall backing and corner details apply. See the section in Chapter 9 on "Interior Rigid Foam Air Barrier." You might be able to expand your business by installing rigid insulation.

BLOWN-IN INSULATION

Blown-in insulation is becoming more popular in the Northwest. In some systems, a light nylon net is stretched over wall cavities and stapled to the studs. The net supports insulation blown into the cavities. The net stays in place beneath the drywall.

An adhesive stabilizes the insulation, preventing it from settling. The adhesive is water-activated, so the blown-in batt goes in damp. It needs time to dry before it is covered. Summer drying time may be 2 to 3 days. The insulation contractor needs to let the general contractor know how much drying time the job needs.

If you see a blown-in product in the home, check with the insulation contractor to verify that the general contractor allowed adequate (at least some) drying time.

Blown-in insulation requires a separate wall vapor retarder: tested vapor retarder paint or polyethylene. If it is paint, the painting contractor is responsible. If it is polyethylene, the insulation contractor or "air tightening specialist" provides the vapor retarder. Poly vapor retarders must be in place before you put up the drywall.

5/8 INCH CEILING DRYWALL

Code homes usually have R-38 ceiling insulation. R-49 is more common in Super Good Cents homes. The extra weight of higher insulation levels is better supported by 5/8 inch drywall. It reduces nail pop and sagging. Use drywall screws rather than nails to provide added support.

Chapter 12

Painting Contractor

Super Good Cents vapor retarder requirements may affect the painting contractor. Most building codes include similar vapor retarder requirements.

VAPOR RETARDER MAY MEAN VAPOR RETARDER PAINT

Vapor retarders in walls and ceilings help keep moisture from inside the home from diffusing into insulation cavities. In some cases, particularly for walls, faced insulation meets the vapor retarder requirement. In other cases, particularly for ceilings, the easiest way to provide the vapor retarder is to apply vapor retarder paint.

If the general contractor expects you to provide vapor retarder paint, check with your suppliers for appropriate products and costs.

Many manufacturers make drywall primer and sealers with perm ratings lower than 1. Both latex and oil base vapor retarder paints are available. Use products with tested perm ratings and follow instructions for applying proper coating thickness.

The testing standard for vapor retarder paint is ASTM E-96-72 or TAPPI specification TT4480M-84. If product literature does not indicate that an independent testing lab used these test standards to verify perm rating, the product may not function as a vapor retarder.

Many building code officials require the test lab report before they accept the paint as the vapor retarder. If you plan to use a particular product frequently, have the manufacturer supply you with a copy of the report. That way you will always be able to verify performance of the paint with general contractors, inspectors, and plan reviewers.

In some cases, codes require that vaulted ceilings have a vapor retarder with a perm rating of 0.5. (The Super Good Cents program requires a perm rating of 1 for walls, ceilings, and floors.) Relatively few vapor retarder paints have ratings that low. But two coats (or more) of the material may provide the protection you need.

Use the following formula to determine the perm rating of multiple coats of paint:

Overall perm rating = $\dfrac{1}{1/P_1 + 1/P_2 + ... + 1/P_n}$

Where:

P_1 = the tested perm rating of the first coat

P_2 = the tested perm rating of the second coat

n = number of coats

For Example:

Product one has a tested (in writing) perm raring of 2.5. The tested perm rating of product two is 1.6. What is the overall perm rating of product one applied over product two?

$$\text{Overall perm rating} = \frac{1}{1/2.5+1/1.6}$$

$$= \frac{1}{0.4 + 0.62}$$

$$= 0.98$$

Remember: To verify that the paint will perform as a vapor retarder, look for independent laboratory tests using ASTM E-96-72 or TAPPI specification TT4,480M-84.

DRYING HOMES WITH POLYETHYLENE VAPOR RETARDERS

Some homes have polyethylene vapor retarders in walls and ceilings. Polyethylene is such an effective vapor retarder that you may need to use fans or dehumidifiers to move moist air out of the home to dry the paint.

In homes with polyethylene in the ceiling, make sure the insulation contractor insulates the ceiling before you paint to prevent condensation at the ceiling and moisture damage to the paint job and drywall.

LONG TERM SUPER GOOD CENTS
PART I
TECHNICAL SPECIFICATIONS
FOR SITE-BUILT SINGLE AND MULTIFAMILY HOMES

TABLE OF CONTENTS

Index to Sections

CHAPTER 1: DESIGN QUALIFICATION AND CERTIFICATION

1.1 **General**: Electrically heated residences meeting the Long-Term Super Good Cents® (LTSGC) requirements meet or exceed the energy efficiency levels specified by the Northwest Power Planning Council in the Model Conservation Standards (MCS) amendment for New Residential and Commercial Construction, published April 1991. These requirements are listed in section 1.2.

Both the Northwest Conservation and Electric Power Plan and the MCS amendment are available from the Northwest Power Planning Council, 851 SW. 6th, Suite 1100, Portland, Oregon 97204, Telephone (503) 222-5161:

1.2 MCS Reference Path for Electrically Heated Residences:

COMPONENT		Zone 1	Zone 2	Zone 3
		(<6000 HDD)	(6-7500 HDD)	(>7500 HDD)
Ceilings 1/	Attic	R-49 Adv.	R-49 Adv.	R-49 Adv.
	Vaults	R-38	R-38	R-38
Walls 1/	Above Grade	R-26 Adv.	R-26 Adv.	R-26 Adv.
	Below Grade Interior with R-5 thermal break 4/	R-21	R-21	R-21
Floors	Over Crawlspaces and Unheated Basements	R-30	R-30	R-38
	Slab-on-Grade Perimeter	R-15	R-15	R-15
Glazing 3/	Maximum tested U-value Reference Area (% of Floor)	U-0.35	U-0.35	U-0.35
	Single Family	15%	15%	15%
	Multifamily	12%	12%	12%
Exterior Doors		U-0.19	U-0.19	U-0.19
Assumed Infiltration Rate 2/ (ACH)		0.35	0.35	0.35
Duct Insulation	Rigid	R-11	R-11	R-11
	Flexible	R-8	R-8	R-8
Water Heaters		***See Section 2.7, Table B***		
Mechanical ventilation and pollutant source control in all Climate Zones.				

1/ Adv. indicates advanced framing techniques. Use standard wall framing and advanced attics for Multifamily structures (6 or more units). Duplexes qualify as Single Family structures.

2/ The assumed infiltration rate (ACH) is for heat-loss calculations only.

3/ Unlimited glazing is acceptable IF all components meet the requirements of this table. Area weighted U-factors for individual components which meet the component requirements of this table are acceptable.

4/ A thermal break having a minimum value of R-5 is required between slab floors and all walls and footings.

Table A - REFERENCE U-FACTORS

Component	Maximum Heat Loss Rate	
Attics	0.020	
Vaults	0.027	
Above-grade Walls	0.041 for single family	0.044 for multifamily
Below-grade Walls (Depth below grade)	U-value	F-value
2 ft.	0.042	0.592
3.5 ft	0.040	0.556
7 ft	0.035	0.503
Floors over unheated spaces	Heating Zones 1 & 2	Heating Zone 3
(U-value)	0.029	0.025
Slab-on-grade (F-value)		0.52

The reference U-factors are both single family and multifamily except as noted.

Advanced-frame walls have studs on 24-inch centers with a double top plate and a single bottom plate. The corners use 2 studs or other means of fully insulating the corners, and 1 stud is used to support each header. The headers have double 2X material with R-10 insulation. The exterior wall cavity is fully insulated at intersections with partition walls. Standard and intermediate wall framing are described in ***Part II of these specifications "Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes."***

An advanced-frame attic is any combination of heel height, insulation material and baffles that provides the required ventilation space and a minimum of R-38 at the interior edge of exterior walls. The insulation shall increase to the full R-value at the highest rate allowed by the roof pitch and taper down to reach the outside edge of the exterior wall or to blocking between rafters.

1.3 Existing Codes and Regulations: These specifications are intended to meet or exceed applicable existing building codes and Federal regulations. In any case where a Federal, State or local code or regulation exceeds these requirements, that code or regulation applies.

1.4 Qualification: To qualify in the Long-Term Super Good Cents Program, a building design must be reviewed and qualified by a representative of a Super Good Cents utility. Unless otherwise stated, "approved" means approved by the Super Good Cents utility.

The building shall meet the MCS energy performance requirements established by the Northwest Power Planning Council (see section 1.2) through one of the following three approaches:

1. Thermal Performance Standards calculated with WATTSUN, Sunday, or other approved methods using the heat-loss coefficients in ***Part II of these specifications "Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes,"*** Except NFRC certified fenestration products which shall use the NFRC labeled U-factor;

2. Energy Budgets calculated with WATTSUN, Sunday, or other approved methods using the heat-loss coefficients in ***Part II of these specifications "Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes,"*** Except NFRC certified fenestration products which shall use the NFRC labeled U-factor; and

3. Prescriptive paths using section 1.2 OR developed by the customer using the prototype houses and instructions in Appendix A of this reference.

1.5 Solar Access: If passive solar design is used to qualify the house, the effective solar glazing shall be 8 percent or more of floor area, there shall be increased thermal mass, common living areas shall be on south side, and solar gains shall be based upon actual sun and shading conditions at the site. Solar designs shall be accompanied by a sun chart, or approved equal, to document actual size conditions for current solar access.

A plot plan shall document future solar access by indicating on the site plan that the solar aperture will not be shaded by a hypothetical 6-foot fence at the southern property line or by a hypothetical "pole" representing average building heights of houses, located at the center of the buildable area of adjacent lots to the south.

Solar glazing shall receive a minimum of 80 percent direct solar exposure between 9 a.m. and 3 p.m. during the heating season.

1.6 Certification: To be certified, the building shall be verified by the Super Good Cents customer to comply with the requirements in this document.

1.7 Additional Utility Requirements: Super Good Cents utilities may add requirements more stringent than those in this specification.

CHAPTER 2: THERMAL EFFICIENCY

2.1 Insulation Coverage: All insulation materials shall be installed according to the manufacturer's instructions to achieve proper densities, avoid compression and voids, and maintain uniform R-values. To the maximum extent possible, insulation shall extend over the full component area to the intended R-value.

2.1.1 General: All insulating materials shall comply with sections 1713 and 1714 of the 1991 Uniform Building Code (UBC) and be installed to meet all applicable fire codes.

2.1.2 Chimneys: Insulation installed around chimneys shall comply with Chapter 37 of the Uniform Building Code (UBC).

2.1.3 Vents and Baffles: Ventilation baffles in attics shall be permanent, weather-resistant retainers and allow insulation to be installed to the outer edge of the exterior wall to the fullest depth possible. All vents for attic/roofs and crawlspaces shall be clear of insulation.

2.1.4 Recessed Fixtures: Recessed fixtures (e.g., medicine cabinets, electrical panels, recessed lights, heating equipment, etc.) shall be covered by the full depth of insulation required by the component assembly. (See section 2.5 for air sealing requirements.)

EXCEPTION: One percent of the component area (e.g., vaulted ceiling, wall) may have a minimum of R-10 insulation between the fixture and the building exterior IF required ventilation clearances are maintained.

2.1.5 Hatches: Hatches connecting conditioned spaces to attics and crawlspaces shall be insulated to at least the requirement for the appropriate component and climate zone except R-38 is allowed for ceiling hatches.

2.1.6 Below-Grade Walls: Below-grade wall insulation shall extend from the top of the wall to the floor on the interior, or to the top of the footing on the exterior.

2.1.7 Rim Joists: All rim joists in heated basements or crawlspaces, or between floors, shall be insulated to the above-grade wall R-value.

2.1.8 Slabs: On-grade slab floor insulation shall be installed along the entire perimeter, and shall extend downwards from the top of the slab a minimum of 24 inches. A combination of vertical and horizontal insulation totaling 24 inches is acceptable.

Slabs in heated spaces shall have an R-5 thermal break between footings and slabs in adjacent unconditioned spaces.

Below-grade slabs shall have an R-5 thermal break between below-grade walls and footings.

Radiant slabs (those heated by hydronic piping or other active slab heating methods) shall have R-15 perimeter insulation and a minimum of R-10 under the remainder of the slab, beneath the heating system.

2.1.9 Hydronic-Heating Pipe Insulation: All exposed pipes in unheated areas used for hydronic heating shall be insulated to a minimum of R-4 using preformed insulation.

2.2 Doors and Glazing: Doors and glazing shall meet the following requirements.

2.2.1 Thermal Ratings: Windows, skylights and sliding glass doors shall be NFRC certified and labeled.

Exterior doors that have not been tested shall use the default U-factors in ***Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes,*** Table 6-1. Entry doors with glazing shall use door default U-factors in ***Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes***, Table 6.2.

2.2.2 Infiltration Ratings: Manufactured doors shall be tested for air infiltration using the ANSI/ASTM E-283-84 "Standard Test Method for Rating of Air-Leakage through Exterior Windows, Curtain Walls, and Doors." The tests shall be conducted at a differential pressure of 1.57 lbf/ft^2 (equivalent to 25 mph wind speed). Doors shall not exceed 0.2 CFM/linear foot of perimeter for swinging doors or 0.25 CFM/ft^2 of door area for sliding doors.

2.2.3 Site-Built Glazing: Where allowed by the utility, site-built, wooden-sash windows shall have a an emissivity coating of 0.2 or less and fit tightly. Fixed lites shall be retained by stops, and sealed. The window frame-to-framing joint shall be sealed. Double-glazed units shall be argon filled and have a minimum space of 1/2-inch between lites. Triple-glazed units shall be argon filled and have a minimum spacing of 1/4-inch between lites.

2.2.4 Site-Built Doors: Where allowed by the utility, site-built doors are exempt from thermal conduction and air infiltration testing, but shall fit tightly. The door frame-to-framing joint shall be sealed.

2.2.5 Weatherstripping: All operable joints in windows and doors shall be weather-stripped.

2.3 Air-Leakage Control: All Long-Term SGC buildings shall use either standard or advanced air-leakage control in section 2.3.1 or 2.3.2 for qualification:

2.3.1 Standard: Each building shall have a tested air-leakage of 7.0 air-changes per hour or less at 50 Pascals, using the procedures in Appendix B of this reference OR comply with the following prescriptive requirements:

All penetrations through the building envelope, including the following, shall be sealed (e.g., caulking, expanding foam, house wrap permeable to water vapor, tape, backer rod, gasket material, etc.) to limit air-leakage.

1. around glazing and door frames, between the unit and the interior sheet rock or the rough framing;

2. over all framing joints where floors intersect exterior walls (e.g., at rim and band joists);

3. at the top and bottom of the mudsill on homes with basements or heated crawlspaces;

4. around openings in the building envelope for access hatches, ducts, plumbing, electricity, telephone, cable television lines in walls, ceilings and floors, and through-the-wall vents;

5. at openings in the ceiling, (e.g., where ceiling panels meet interior and exterior walls, at exposed beams, masonry fireplaces, woodstove flues, etc.); and

6. around all outlet, switch, or other electrical boxes in the exterior walls, ceilings, or floors.

In addition to the above, multifamily buildings (6 or more units) shall also be sealed at all penetrations into joist spaces between floors.

2.3.2 Advanced: Buildings shall have tested air for leakage according to the procedures in Appendix B of this reference and shall have 1.8 air-changes per hour at 50 Pascals.

2.4 Backdraft Dampers: Intermittently-operated fans, or other non-heat-recovery systems, exhausting air from the building shall be ducted to the outside and have a backdraft or automatic damper in the exhaust duct.

2.5 Recessed Fixtures: Recessed fixtures (e.g., wall heaters, fans, medicine cabinets, electrical panels, etc.) shall be sealed to the component assembly to restrict air-leakage.

Recessed light fixtures shall meet ONE of the following requirements:

1. they must be IC-rated, double-can units sealed around the exterior to be air tight,

2. IC-rated units or fluorescent fixtures installed in a sealed "box" that extends the ceiling above the light fixture, or

3. type IC-rated units, certified under ASTM E-283 to have no more than 2.0 cfm air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested without the trim at 75 Pascals or 1.57 lbs/ft^2 pressure difference, and have an attached label showing compliance.

The mounting flange on the exterior of the can, or the sealed "box," must be caulked to the ceiling finish/air barrier.

2.6 Wood stoves, Fireplaces and Other Combustion Appliances: Vented combustion appliances inside the heated space shall meet the requirements of sections 2.6.1 through 2.6.3 below. Unvented combustion appliances are NOT acceptable.

2.6.1 Woodstoves and Fireplaces: Masonry and factory-built fireplaces and woodstoves shall be installed with the following features:

1. Doors: Closeable metal or glass doors covering the entire opening of the firebox.

2. Combustion Air: Combustion-air intakes supplying primary combustion air to the appliance shall be sized as follows:

a. for factory-built wood-burning stoves, inserts, or fireplaces as specified by the manufacturer, but not less than 4 inches in diameter and not more than 20-feet in length.

b. for site-built appliances (e.g., masonry fireplaces, etc.), at least 4 inches in diameter and not more than 20-feet in length.

3. Fireplace Flue Dampers: For solid-fuel burning fireplaces only, a tight-fitting flue damper with a readily accessible control.

2.6.2 Other Combustion Appliances: All other combustion appliances inside the heated space shall be provided with outside primary combustion-air ducted directly to the appliance.

EXCEPTION: Gas cooking appliances without outside combustion-air shall have an exhaust fan directly serving those appliances that exhausts air to the outside.

EXCEPTION: Gas clothes dryers.

2.6.3 Combustion Exhaust: All combustion exhausts shall be separated by a minimum of 3-feet vertically or 10-feet horizontally.

2.7 Electric Water Heaters: Water heaters shall have GAMA certified minimum EF (Energy Factor) not less than specified in the Table B for the appropriate tank storage volume.

Table B - Electric Water Heater Efficiency Standards

Tank Size (gallons)*	Energy Factor
30	0.96
40	0.94
50	0.93
65	0.91
80	0.89
120	0.84
*The rated storage volume, which equals the storage capacity of the water heater, in gallons, as specified by the manufacturer.	

Water heaters on concrete basement or slab-on-grade floors shall be placed on a noncompressible insulating pad of R-10 or greater if full underslab insulation is not present. R-10 insulation shall also be placed under water heaters on raised platforms in unheated spaces.

Gas water heaters are exempt from the efficiency and insulating pad requirements.

CHAPTER 3: HEATING SYSTEMS

3.1 General: The primary heating system in Long-Term Super Good Cents homes shall be electric. The heating contractor is responsible for designing and installing the heating system to meet all UMC, NEC, applicable local codes and equipment manufacturer's requirements.

3.2 Control Requirements: Each separate heating system shall have at least one thermostat per zone mounted on an interior wall, at the manufacturer's recommended height, to regulate temperature. Each thermostat shall have numerical degree settings.

3.2.1 Central Systems (Non-Heat Pump): For central furnace or similar type systems, a low-voltage, heat-anticipating or microprocess-controlled electronic thermostat shall be installed.

3.2.2 Zonal Systems: There shall be one heat-anticipating, bi-metal thermostat OR a microprocessor-controlled electronic thermostat per zone.

3.2.3 Heat Pumps:

3.2.3.1 Installation

Indoor thermostats should be located and installed according to the manufacturer's instructions and recommendations. Thermostats generally are installed 5 feet off the floor on an inside wall in the return airflow pattern, and where they are not in the sun or any other heat source at any time.

3.2.3.2 Heating and Cooling

Thermostats used for both heating and cooling shall have a manual changeover feature or heating/cooling lockout to prevent cross-cycling between heating and cooling.

3.2.3.3 Automatic Setback (optional)

Indoor thermostats may have the capability of automatically reducing heating thermostats set point during unoccupied hours, and lockout strip heat during warmup by outdoor thermostats or an electronic programmed thermostat which shall control the strip heat on warm up.

3.2.3.4 Energy Heat Relay

All indoor thermostats shall include a manual selector switch to permit all supplemental heaters or the furnace to be energized under control of the indoor thermostat (with the compressor and outdoor thermostats bypassed) when the compressor or refrigerant system is inoperative. An indicator light, which is energized whenever the system is operating on emergency heat, shall be provided.

3.2.3.5 Microprocessor Thermostats

The first stage of electric heat shall be controlled by the second stage of the indoor thermostat. Thermostats should indicate auxiliary stage and emergency heat.

3.3 HVAC Ducts: HVAC ducts shall meet the following requirements:

3.3.1 All HVAC supply and return ducts, air handlers, and plenums inside and outside the heated space shall be sealed at all joints and corners, including prefabricated joints and longitudinal seams. Recommended sealing methods include mastic, foil tape with a 15-mil butyl sealant, or cleaning the joint with a suitable solvent and sealing with a UL-181 listed tape.

3.3.2 All rigid metal ducts and plenums outside the heated space shall be insulated to at least R-11 and a vapor barrier shall be installed on the outside surface.

3.3.3 All new ducts and plenums that are internally lined with insulation outside the heated space shall be installed in accordance with SMACNA's Duct Liner Application Standard, second edition. The total R-value of this duct work shall be no less than R-8.

3.3.4 All flexible HVAC ducts outside the heated space shall have an Air Diffusion Council (ADC) certified minimum R-value of R-8.

3.3.5 All HVAC ducts routed within exterior wall cavities shall be insulated to a minimum of R-14 between the duct and the exterior wall sheathing.

3.3.6 All joints in the air handler and the HVAC ducts shall be mechanically fastened. Flexible ducts shall be attached using nylon/plastic straps tightened with a manufacturer approved tool (hand tightening is not acceptable) or stainless steel worm drive clamps. Mastic and duct tape shall not be used as mechanical fasteners.

3.3.7 All HVAC ducts, connectors, etc., that will be enclosed in concrete shall be insulated with a minimum of R-8 rigid insulation before the concrete is poured.

3.3.8 Flex duct is not recommended for runs greater than 4 feet,

Exception - Additional flex duct may be used when supply and return ducts do not have more than 0.10 and 0.08 inches of static pressure per 100 feet respectively. (Usually cannot be met using flex duct).

3.3.9 Maximum Velocities

Duct work shall be designed so air velocities do not exceed the following:

Supply Ducts

Main Ducts	900 FPM
Branch Ducts	600 FPM
Registers, Diffusers and Grills (face velocity)	500 FPM

Return air shall be sufficient size to meet requirements of installed systems.

3.3.10 Proper diffusers and registers shall be selected and installed in the proper locations.

3.3.11 Branch out runs should be a minimum of 6 inches in diameter except to bathrooms.

CHAPTER 4: MOISTURE AND AIR QUALITY

4.1 Moisture Vapor Transfer: The following shall be installed to limit moisture transfer:

4.1.1 General: A vapor retarder of not more than 1.0 perm shall be installed in, or applied to, exterior walls, ceilings, and floors. It shall be installed according to the manufacturer's specifications, on the warm side (in winter) of all insulation. The retarder shall be considered to be on the warm side if the R-value of the materials between it and the heated space is not more than 33 percent of the total R-value of the component section at the insulated cavity.

4.1.2 Slab Floors: Slab floors shall have a minimum of 4 inches of sub-slab gravel meeting ONE of the following requirements:

1. ASTM Standard C33, "Standard Specifications for Concrete Aggregates," or any successor standards, and shall be size Number 67 or larger size aggregate as listed in Table 2, Grading Requirements for Coarse Aggregates; or,

2. the 1988 Washington State Department of Transportation specifications 9-0.31(3), "Coarse Aggregate for Portland Cement Concrete," or any successor standards, and aggregate size shall be of Grade 5 or larger size aggregate as listed in 9-03.1(c), "Grading;" or,

3. is screened, washed, free of deleterious substances in a manner consistent with ASTM C33, with 100 percent of the gravel passing a 1-inch sieve and less than 2 percent passing a #4 sieve. Sieve characteristics shall conform to those acceptable under ASTM C33.

4.1.3 Crawlspace Ground Cover: In crawlspaces, a ground moisture barrier of 6-mil black polyethylene, or equal approved by the utility, shall be installed covering the entire ground surface of the crawlspace.

4.2 Attic and Crawlspace Ventilation: Outdoor air ventilation shall be provided in the following places, at the following rates:

4.2.1 Attics/Ceilings: Adequate cross ventilation shall be maintained above all ceiling insulation by providing both low and high vents. At least 1 ft^2 of net-free vent area shall be provided for every 300 ft^2 of ceiling area with 50-to-60 percent of the vent area located near the roof ridge and 40-to-50 percent located near the eaves. One-level venting may be used if at least 1 ft^2 of net-free vent area is provided for every 150 ft^2 of ceiling area and adequate cross ventilation can be maintained.

4.2.2 Crawlspaces: Crawlspaces shall be ventilated by openings in at least two opposing exterior foundation walls with a net-free vent area of not less than 1 ft^2 for each 150 ft^2 of underfloor area. Where local code allows, this ventilating area may be reduced to 1 ft^2 for every 300 ft^2 of underfloor area if the crawlspace soil is dry, well drained and a ground cover meeting the provisions of 4.1.3 has been installed.

Where allowed by code, mechanical ventilation of 2 ACH or higher is acceptable.

4.3 Mechanical Ventilation: Whole-house ventilation systems, which include exhaust-air fans and outside-air intakes, are required and shall be designed and controlled to provide adequate ventilation for the occupants while minimizing energy penalties.

Whole-house ventilation systems shall use remotely-mounted exhaust fans (i.e. more than 4-feet from the pick-up grille) or surface-mounted fans (i.e. exhaust fan motors within 4-feet of the pick-up grille). Surface-mounted fans shall have a sone rating of 1.5 or less for intermittently-operating systems and 1.0 or less for continuously-operating systems. Both remotely and surface-mounted fans shall installed to limit the transmission of fan vibrations to the building structure. Intermittently-operating whole-house ventilation fans shall be controlled by 24-hour timers, with a minimum of 2 on-periods per day, and shall be set to operate for a minimum of 8 hours per day.

Multifamily buildings (6 or more units) shall have one of the following ventilation systems for each unit:

1. a continuously-operating ventilation system providing a measured minimum airflow of 0.35 air-changes per hour (ACH) or 15 cfm for each bedroom and 15 cfm for the main living area with a maximum rate of 0.5 ACH, or meet the prescriptive requirements using the HVI certified fan flows in the following table.

TABLE C: Multifamily Continuous Ventilation

Number of Bedrooms	Minimum Certified Fan Flow at 0.25 in W.G.	Maximum Certified Fan Flow at 0.25 in W.G.
1	30 cfm	60 cfm
2	50 cfm	75 cfm
3	60 cfm	90 cfm
4	80 cfm	120 cfm

When the whole-house fan provides pickups in, or is located in, the bathroom or kitchen in lieu of spot ventilation fans, the whole-house fan shall exhaust 20 cfm from the bathroom and/or 25 cfm from the kitchen. A single, continuously-operating, integrated and whole-house fan, or fan pickup, in one bathroom is acceptable if spot ventilation fans are provided in the kitchen and in the other bathrooms.

2. an integrated HVAC ventilation system (option 4) described below for single family ventilation if it is provided by a separate HVAC system for each unit, or

3. an intermittently-operating system exhausting not less than 1.5 times the minimum prescriptive flow rates in Table A above. Intermittent exhaust devices may replace one more spot ventilation devices IF all spot ventilation requirements are met.

Single-family buildings (5 or fewer units) shall provide whole-house ventilation systems which exhaust indoor air at the rates specified in section 4.3.1 for each unit. The four general system designs for single-family residences are:

1. Integrated Spot and Whole-House Design: This system uses one or more exhaust fans to provide spot and whole-house ventilation. The fan(s) is controlled by both a manual switch, crank timer, or dehumidistat in the bathroom for spot ventilation AND a 24-hour timer to provide whole-house ventilation.

2. Continuous Ventilation: This system uses a continuously-operating fan to exhaust air at a minimum rate of 25 cfm for the kitchen and 20 cfm per bathroom, with a maximum rate of 0.5 ACH.

   A fan exhausting air from the kitchen and from each bathroom also provides spot ventilation. An integrated spot and whole-house fan is acceptable if spot ventilation is also provided for the kitchen and for all bathrooms.

3. Discrete Spot and Whole-House Design: This system uses separate exhaust fans and control systems to provide spot and whole-house ventilation.

Spot Ventilation is provided by standard bath fans controlled by a manual switch, crank timer or dehumidistat, and a kitchen range hood. Whole-house ventilation is provided by a fan, controlled by a 24-hour timer, that exhausts air from a central hallway near the bedrooms.

4. Forced-Air Heating/Cooling System Integrated Design: In this system, the forced-air heating/cooling system is used to bring outside air into the return-air plenum and distribute it through the supply ducts. Spot ventilation is provided by bathroom and kitchen exhaust fans

   A 24-hour timer, controls the heating/cooling system air handler, a motorized damper in the outside-air supply duct, and an exhaust fan to provide ventilation and to reduce building pressurization.

   An outside-air supply duct meeting the diameter and length requirements in section 4.3.7.2, is connected to the return-air plenum within 36 inches of the air handler. The outside-airflow is controlled by a balancing damper or constant airflow regulator in the outside-air supply duct to meet the airflow specified in section 4.3.1.

4.3.1 Exhaust Airflow Rates: Exhaust airflow rates shall meet either the following Performance or Prescriptive requirements.

Performance Path: The minimum combined measured airflow capacity for whole-house exhaust systems shall be 0.35 ACH, but not less than 15 cfm per bedroom and 15 cfm for the main living area. The maximum ventilation rate for non-heat recovery ventilation systems shall not exceed 0.5 ACH for houses of 1400 ft^2 or larger or 0.65 ACH for houses smaller than 1400 ft^2.

Prescriptive Path: Whole-house ventilation systems that do not meet the performance path shall meet the HVI certified fan flow requirements, minimum duct diameters, and maximum duct lengths listed in this section.

TABLE D: Single Family Intermittent Ventilation

Number of Bedrooms	Minimum Certified Fan Flow at 0.25 in W.G.	Maximum Certified Fan Flow at 0.25 in W.G.
2 or less	50 cfm	75 cfm
3	80 cfm	120 cfm
4	100 cfm	150 cfm
5	120 cfm	180 cfm

Fans shall be certified by HVI at 0.25 inches water gauge as determined by HVI 916 (July 1993)..

The following table gives the minimum duct diameter, maximum duct length and maximum number of elbows for smooth ducts or 90 degree bends in flexible ducts based upon fan size.

TABLE E: Exhaust-Fan Duct Length vs. Diameter

	FLEX DUCT		SMOOTH DUCT		
FAN TEST Max CFM @ .25 W.G.	Flex Duct Diameter	Maximum Length Feet	Smooth Duct Diameter	Maximum Length Feet	MAXIMUM # 90° Elbows*
50	4"	25	4"	70	3
50	5"	90	5"	100	3
50	6"	No limit	6"	No limit	3
80	4"	Not allowed	4"	20	3
80	5"	15	5"	100	3
80	6"	90	6"	No limit	3
100	5"	Not allowed	5"	50	3
100	6"	45	6"	No limit	3
125	6"	15	6"	No limit	3
125	7"	70	7"	No limit	3

* Subtract 10-feet from the maximum duct length for each additional elbow

4.3.2 Exhaust-Duct Insulation: All exhaust ducts in unheated spaces shall be insulated to at least R-4.

4.3.3 Exhaust Duct Termination: Exhaust ducts shall terminate outside the residence in a fitting with an area not less than the area of the duct.

4.3.4 Spot Ventilation: Spot ventilation fans, ducted to the outside of the envelope and meet the minimum capacities listed in the following table. The fan shall be certified at 0.25 inches of water gauge as determined by HVI 916 (July 1993). Kitchen range hoods or down-draft range exhaust fans may be rated at 0.1 inches of water gauge.

TABLE F: Spot-Ventilation Fan Capacity

Location	Certified Fan Capacity
Each bathroom	50 cfm
Kitchen	100 cfm

Exception: Separate spot ventilation is not required for a continuously-operating system which exhausts 25 cfm from the kitchen and 20 cfm from each bathroom.

4.3.5 Backdraft Dampers: A tight-fitting backdraft damper, capable of closing when intermittently-operating fans are not in use, shall be provided in each exhaust duct.

4.3.6 Controls: Intermittently-operating, whole-house exhaust fans shall have both automatic and manual controls. Automatic controls shall include a time clock or cycle timers with a minimum of two on-periods per day and be set to provide at least 8 hours of mechanical ventilation per day.

A manual override switch accessible to, and controllable by, occupants allows occupants to run the fan continuously or disable it if desired.

Parallel Wiring: The spot and whole-house ventilation controls may be wired in parallel, allowing the same fan to perform both functions. A whole-house exhaust fan, for example, may be wired to both the manual spot-ventilation switch in the bathroom and to a time clock.

4.3.7 Outside-Air Supply: The outside-air may be supplied by following the requirements of section 4.3.7.1 OR section 4.3.7.2 below.

1. Fresh-Air Inlets: Individual outside-air inlets shall:

- be located to avoid drafts,
- have a controllable and secure opening,
- be sleeved or otherwise designed to prevent compromising the thermal integrity of the wall or window into which it is placed, and
- provide a total opening area of at least 4 in^2 of net-free area or be HVI certified to provide 10 cfm at 10 Pascals for each bedroom and for each 300 ft^2 of combined living area.

2. Central Outside-Air Duct: A central duct providing outside-air directly to the return plenum of a forced-air heating/cooling system which circulates fresh air to the required rooms (used with Forced Air Heating/Cooling System Integrated Design). This duct shall have a motorized damper and a flow-control device to provide a supply airflow equal to the exhaust airflow rates specified in section 4.3.1. Duct diameter and length shall meet the following requirements:

TABLE G: Option 4 Air-Inlet Duct Length vs. Diameter

Number Of Bedrooms	Minimum Smooth Duct Diameter	Minimum Flex Duct Diameter	Maximum Duct Length 1/	Maximum Number of Elbows 2/
2 or less	6"	7"	20 ft	3
3	7"	8"	20 ft	3
4 or more	8"	9"	20 ft	3

1/ For lengths over 20-feet, increase the duct diameter by 1-inch.
2/ For more than 3 elbows, increase the duct diameter by 1-inch.

4.3.8 Outside-Air Source: The outside-air shall come from outside the building envelope and shall not be taken from the following locations:

- within 10-feet of an exhaust vent or combustion appliance flue outlet unless the vent/outlet is at least 3-feet above the air inlet
- where it will pick up objectionable odors, fumes, or flammable vapors
- a hazardous or unsanitary location
- a room or space containing any fuel-burning appliance
- within 10-feet of a plumbing vent unless the vent is at least 3-feet above the air inlet
- attics, crawlspaces, or garages

Protection: The outside-air source shall have adequate protection from entry by rain, insects, leaves, and other objects.

Flow Control: The outside-air source shall limit excessive airflows under normal operation.

4.3.9 Outside-Air Distribution: Adequate outside-air distribution shall be provided by individual room inlets, separate duct systems, or a forced-air system.

Where outside-air supplies are separated from the exhaust points, undercut doors, door or wall grilles, transoms grilles, or other approved means shall be provided to allow air circulation between spaces.

4.4 Formaldehyde Reduction Measures: All structural panel components of the house such as softwood plywood, particle board, wafer board, and oriented strand board shall be identified as "EXPOSURE 1," "EXTERIOR," or "HUD-Approved."

APPENDIX A

PRESCRIPTIVE OPTIONS FOR SITE-BUILT, SINGLE FAMILY HOUSING

1. Scope: This Appendix describes how utilities can develop prescriptive paths for Single Family residences in their service areas. Each prescriptive path must equal or exceed the base case for the appropriate climate zone and be approved by Bonneville. Each trade-off item must be an approved SGC measure.

2. Procedure: Using WATTSUN, SUNDAY, or other approved software, calculate the Thermal Performance or Energy Budget for ALL THREE prototype houses in the following table. All three prototypes must equal or exceed the base case for each prescriptive path.

PROTOTYPE COMPONENT AREAS

Component	Rambler 1344 ft^2	Split Level 1848 ft^2	Daylight Basement 2356 ft^2
Crawlspace floor	1344	1288	468
On-grade slab			30 lin. ft.
Below-grade wall @ 3.5 ft. average			544
Below-grade slab @ 3.5 ft. average			124 lin. ft.
Above-grade wall	1136	1732	1489
Windows	200	276	353
Doors	40	40	40
Flat ceiling	1344	1288	1160
Vaulted Ceiling			270
Volume	10752	14784	19833

APPENDIX B

BLOWER DOOR TEST PROTOCOL

1. Scope: This Appendix describes the blower door test protocol for testing the air-leakage of a single family house and representative residences in multifamily structures to meet the requirements of sections 2.3 of the Specifications.

2. When to Test: Testing shall occur after everything is roughed-in/ installed that will penetrate the building envelope (e.g., plumbing, electrical, HVAC, ventilation, combustion appliances, etc.) and the air barrier has been installed.

   Do not test when the outside wind speed exceeds 15-20 miles per hour.

3. House/Residence Preparation: All single family houses and representatives residences in multifamily structures shall be checked before testing to assure that following preparation measures have been completed.

   3.1 Building envelope: All windows and doors shall be properly closed, including pass-through wood-box doors and pet doors. All interior doors shall be left open.

   3.2 Ventilation openings: All exhaust fan openings, vent openings, and intake-air vents with backdraft dampers (e.g., dryer vents and kitchen, bathroom, utility room, whole-house, range vents, etc.) shall NOT be sealed.

   Exterior vent openings without backdraft dampers (e.g., some continuous ventilation systems) shall be temporarily sealed for the test. Heat recovery ventilator supply openings shall be sealed. Heat recovery ventilator exhaust openings should have backdraft dampers and shall not be sealed.

   3.3 Forced-air heating systems: Supply and return registers shall NOT be sealed and the heating system shall be turned off. HVAC ducts shall be tested with the envelope. Dampers in the outside-air supply duct into the return plenum shall be closed.

   3.4 Combustion appliances: All flue dampers, fireplace doors, and wood burning stove doors shall be closed, but NOT sealed.

4. Equipment Set-up: The blower door equipment shall be set-up using the following procedure:

   a. Keep the gauges at room temperature if possible. Cold temperatures may affect gauge accuracy.

   b. Install the blower-door assembly and seal all cracks and holes.

   c. Set up the gauge assembly with the gauges plumb and level.

   d. Attach a hose to the indoor pressure tap. Place the free end of the hose indoors away from the fan airflow path at the approximate height of the fan centerline.

   e. Exercise the gauges by blowing and sucking on the hoses to drive the gauges over their entire range six to eight times. Install the fan orifice plate, plug or seal all holes, and adjust the gauges to zero..

   f. Start the fan and depressurize the house to check for anomalies in the building envelope.

5. Performing the Test: Perform the test using the following procedures:

   a. Depressurize the house to 55 Pascals and reduce the pressure to 50 Pascals (0.205 inches of water).

   b. Tap the gauge to reduce stored spring energy from the gauge needle and wait for the needle to stabilize before recording the readings.

   c. View the gauge from directly in front when taking a reading. Maintain a consistent line of sight to avoid parallel errors or distortions from the gauge cover.

   d. Increase the pressure again and then retest at 50 Pascals.

6. Multifamily Structures: In multifamily structures, one corner and one middle apartment on each floor shall be tested according to the above protocol as representative residences. The apartment weighted average of the ACH @ 50 Pascals for the tested apartments shall be calculated for compliance with section 2.3 of the specifications.

LONG-TERM SUPER GOOD CENTS PROGRAM
PART II
DEFAULT HEAT-LOSS CO-EFFICIENTS
FOR SITE-BUILT SINGLE AND MULTIFAMILY HOMES

TABLE OF CONTENTS

CHAPTER 1: GENERAL

1.1 Scope: This Reference includes tables of seasonal average heat-loss coefficients for specified nominal insulation levels in the Super Good Cents program.

It also includes default U-values for windows and doors (15 mph table), which may be used as substitutes for the tested U-values required for glazing in section 2.2 in the Technical Specifications.

The heat-loss coefficients may also be used for heating system sizing.

1.2 Description: These coefficients were developed primarily from data and procedures in the 1989 ASHRAE Handbook of Fundamentals. Additional procedures, developed by Ecotope Inc., are detailed in the Super Good Cents Heat-Loss Reference Manual.

Co-efficients not contained in this Reference may be computed using the procedures listed in these references if the assumptions in the following sections and the SGC Heat-Loss Reference Manual are used, along with data from the sources referenced above.

CHAPTER 2: BELOW GRADE WALLS and SLABS

2.1 General: Table 2.1 lists heat-loss coefficients for below-grade walls and floors.

Co-efficients for below-grade walls are given as U-values (BTU/°F-hr per square foot of wall area). Co-efficients for below-grade slabs are listed as F-values (BTU/°F-hr per lineal foot of slab perimeter). They are derived from simulations using models and procedures developed by Ecotope, Inc., which are described in more detail in Volume I of the Super Good Cents Heat-Loss Reference.

Below-grade wall U-values are only valid when used with the accompanying below-grade slab F-value, and vice versa.

2.2 Component Description: All below-grade walls are assumed to be 8-inch concrete. The wall is assumed to extend from the slab upward to the top of the mud sill for the distance specified in Table 2.1, with 6 inches of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2x4 framing on 24-inch centers with 1/2-inch of gypsum board as the interior finish material. Exterior insulation is assumed to be applied directly to the exterior of the below-grade wall from the top of the wall to the footing. The exterior case does not assume any interior framing or sheetrock.

In all cases, the entire wall surface is assumed to be insulated to the indicated nominal level with the appropriate framing and insulation application. Co-efficients are listed for wall depths of 2, 3.5, and 7-feet below grade. Basements shallower than 2-feet should use on-grade slab coefficients.

Heat-loss calculations for wall areas above grade should use above-grade wall U-values, beginning at the mudsill.

2.3 Insulation Description: Co-efficients are listed for the following four configurations:

1. Uninsulated: No insulation or interior finish.

2. Interior insulation: Interior 2x4 insulated wall without a thermal break between concrete wall and slab.

3. Interior insulation w/thermal break: Interior 2x4 insulated wall with R-5 rigid board providing a thermal break between the concrete wall and the slab.

4. Exterior insulation: Insulation applied directly to the exterior surface of the concrete wall.

TABLE 2-1
DEFAULT WALL U-VALUES AND SLAB F-VALUES FOR BASEMENTS

	Below Grade Wall U-value	Below Grade Slab F-value
2-Foot Depth Below Grade		
Uninsulated	0.350	0.59
R-11 Interior	0.066	0.68
R-11 Interior w/tb	0.070	0.60
R-19 Interior	0.043	0.69
R-19 Interior w/tb	0.045	0.61
R-10 Exterior	0.070	0.60
3.5-Foot Depth Below Grade		
Uninsulated	0.278	0.53
R-11 Interior	0.062	0.63
R-11 Interior w/tb	0.064	0.57
R-19 Interior	0.041	0.64
R-19 Interior w/tb	0.042	0.57
R-10 Exterior	0.064	0.57
7-Foot Depth Below Grade		
Uninsulated	0.193	0.46
R-11 Interior	0.054	0.56
R-11 Interior w/tb	0.056	0.42
R-19 Interior	0.037	0.57
R-19 Interior w/tb	0.038	0.43
R-10 Exterior	0.056	0.42

CHAPTER 3: ON-GRADE SLAB FLOORS

3.1 General: Table 3.1 lists heat-loss coefficients for heated on-grade slab floors, in units of BTU/°F-hr per lineal foot of perimeter. They are derived from simulations using models and procedures developed by Ecotope, Inc., and described in more detail in Volume I of the Super Good Cents Heat Loss Reference.

3.2 Component Description: All on-grade slab floors are assumed to be 6-inch concrete poured directly onto the earth. The bottom of the slab is assumed to be at grade line. Monolithic and floating slabs are not differentiated.

Soil is assumed to have a conductivity of 0.75 BTU/Hr-°F-ft^2. Slabs 2-feet or more below grade should use basement coefficients.

3.3 Insulation Description: Co-efficients are provided for the following three configurations:

2-Foot (or 4-foot) vertical: Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2-feet (or 4-feet) below grade.

2-Foot (or 4-Foot) horizontal: Insulation is applied directly to the underside of the slab, and run horizontally from the perimeter inward for 2-feet or 4-feet. The slab edge is exposed in this configuration.

Note: A horizontal installation with a thermal break of at least R-5 at the slab edge should use the vertical-case F-values.

Fully insulated slab: Insulation extends from the top of the slab, along the entire perimeter, and completely covers the area under the slab.

TABLE 3-1

DEFAULT F-VALUES FOR ON-GRADE SLABS

Insulation Type	R-0	R-5	R-10	R-15
Uninsulated slab	0.73	--	--	--
2-ft Horizontal (No thermal break)	--	0.70	0.70	0.69
4-ft Horizontal (No thermal break)	--	0.67	0.64	0.63
2-ft Vertical (or Horiz. w/T.B.)	--	0.58	0.54	0.52
4-ft vertical (or Horiz. w/T.B.)	--	0.54	0.48	0.45
Fully insulated slab	--	--	0.36	--

CHAPTER 4: CRAWLSPACE FLOORS

4.1 General: Tables 4.1 through 4.3 list heat-loss coefficients for floors over crawlspaces in units of BTU/°F-hr per square foot of floor.

They are derived from procedures listed in the 1989 ASHRAE Handbook of Fundamentals assuming an average outdoor temperature of 45°F, an average indoor temperature of 65°F, and a crawlspace area of 1350 ft^2 and 150 ft of perimeter. The crawlspace is assumed to be 2.5-feet high, with 24 inches below grade and 6 inches above grade.

4.2 Crawlspace Description: Four crawlspace configurations are considered: vented, unvented, enclosed and heated plenum.

Vented crawlspaces: Assumed to have three air-changes per hour, with at least 1 ft^2 of net-free ventilation in the foundation for every 300 ft^2 of crawlspace floor area. The crawlspace is not actively heated.

Floors over unheated areas, such as garages, may only use those values which have R-0 perimeter insulation.

Unvented crawlspaces: Assumed to have 1.5 air changes per hour, with less than 1 ft^2 of net-free ventilation in the foundation for every 300 ft^2 of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated basements may only use those values which have R-0 perimeter insulation.

Heated-plenum crawlspaces: Assumed to have 0.25 air-changes per hour, with no foundation vents. Heated supply air from central furnace is blown into a crawlspace and allowed to enter the living space unducted via holes cut into the floor.

Enclosed floors: Assumes no buffer space, and a covering of 1/2-inch of T1-11 on the exterior of the cavity exposed to the outside air.

4.3 Construction Description: Floors are assumed to be either joisted floors framed on 16-inch centers, or post and beam on 4 by 8 foot squares. Insulation is assumed to be installed under the subflooring between the joists or beams with no space between the insulation and the subfloor. Insulation is assumed to be uncompressed.

Perimeter insulation is assumed to extend from the the top of the rim joist to the crawlspace floor and then inward along the ground (on top of the ground cover) for at least 24 inches.

Floor coverings are assumed to be light carpet with rubber pad.

TABLE 4-1

DEFAULT U-VALUES FOR FLOORS OVER VENTED CRAWLSPACE

Nominal R-value		U-value	
Floor	**Perimeter**	**Post & Beam**	**Joists**
0	0	0.112	0.134
	11	0.100	0.116
	19	0.098	0.114
	30	0.093	0.107
11	0	0.052	0.056
	11	0.048	0.052
19	0	0.038	0.041
	11	0.036	0.038
22	0	0.034	0.037
	11	0.033	0.035
25	0	0.032	0.034
	11	0.031	0.033
30	0	0.028	0.029
	11	0.027	0.028
38	0	0.024	0.025
	11	0.024	0.024

TABLE 4-2

DEFAULT U-VALUES FOR FLOORS OVER UNVENTED CRAWLSPACE OR BASEMENT

Nominal R-value		U-value	
Floor	**Perimeter**	**Post & Beam**	**Joists**
0	0	0.101	0.119
	11	0.080	0.090
	19	0.076	0.085
	30	0.073	0.082
11	0	0.049	0.053
	11	0.044	0.047
	19	0.042	0.045
	30	0.042	0.044
19	0	0.037	0.040
	11	0.034	0.036
	19	0.033	0.035
22	0	0.033	0.035
	11	0.031	0.033
25	0	0.031	0.033
	11	0.029	0.030
30	0	0.027	0.029
	11	0.026	0.027

TABLE 4-3

DEFAULT U-VALUES FOR FLOORS OVER HEATED PLENUM CRAWLSPACES

Nominal R-value Perimeter	U-value
11	0.085
19	0.075
30	0.069

Note: Crawlspaces used as heated plenums have approximately 30 percent higher heat-loss rate than unvented crawlspaces with the same assumed ACH. Default U-values in Table 4-3 reflect this higher rate of heat loss.

TABLE 4-4

DEFAULT U-VALUES FOR ENCLOSED FLOORS

Nominal R-value		U-value	
Floor	Perimeter	Post & Beam	Joists
0	0.223	21	0.042
11	0.067	22	0.043
13	0.060	25	0.037
15	0.055	30	0.033
19	0.046	38	0.027

CHAPTER 5: ABOVE-GRADE WALLS

5.1 General: Table 5.1 lists heat-loss coefficients for the opaque portion of above-grade walls (BTU/°F-hr per square foot). They are derived from procedures listed in the 1989 ASHRAE Handbook of Fundamentals assuming exterior air films at 7.5-mph wind speed.

Insulation is assumed to uniformly fill the entire cavity and to be installed as per manufacturer's directions. All walls are assumed to be finished on the inside with 1/2-inch gypsum wallboard, and on the outside with either beveled wood siding over 1/2-inch plywood sheathing or with 5/8-inch T1-11 siding. Insulated sheathing (either interior or exterior) is assumed to cover the entire opaque wall surface.

5.2 Framing Description: Three framing types are considered, and defined as follows:

Standard: Studs framed on 16-inch centers with double top plate and single bottom plate. Corners use 3 studs and each opening is framed using 2 studs. Headers consist of double 2X or single 4X material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use 2 studs in the exterior wall.

Framing weighting factors:	Studs and plates	.19
	Insulated cavity	.77
	Headers	.04

Intermediate: Studs framed on 16-inch centers with double top plate and single bottom plate. Corners use 2 studs or other means of fully insulating corners, and each opening is framed by 2 studs. Headers consist of double 2X material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Framing weighting factors:	Studs and plates	.18
Insulated cavity		.78
Headers		.04

<u>Advanced</u>: Studs framed on 24-inch centers with double top plate and single bottom plate. Corners use 2 studs or other means of fully insulating corners, and 1 stud is used to support each header. Headers consist of double 2X material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Framing weighting factors:	Studs and plates	.13
Insulated cavity		.83
Headers		.04

5.3 <u>Component Description:</u> Default coefficients for three types of walls are listed: single stud walls, strap walls, and double-stud walls.

<u>Single Stud Wall</u>: Assumes either 2x4 or 2x6 studs framed on 16 or 24-inch centers. Headers are solid for 2x4 walls and double 2x for 2x6 walls, with either dead-air or rigid-board insulation in the remaining space.

<u>Strap Wall</u>: Assumes 2x6 studs framed on 16 or 24-inch centers. 2x3 or 2x4 strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

<u>Double-Stud Wall</u>: Assumes an exterior structural wall and a separate interior, nonstructural wall. Insulation is placed in both wall cavities and in the space between the two walls. Stud spacing is assumed to be on 24-inch centers for both walls.

TABLES 5-1

DEFAULT U-VALUES FOR ABOVE-GRADE WALLS

2 x 4 Single Stud: R-11 Batt

	R-value of Foam Board	Lapped STD	Wood ADV	T1-11 STD	T1-11 ADV
NOTE: Nominal Batt R-value: R-11 at 3.5-inch thickness	0	.088	.084	.094	.090
	1	.080	.077	.085	.082
Installed Batt R-value:	2	.074	.071	.078	.075
R-11 in 3.5-inch cavity	3	.069	.066	.072	.070
	4	.064	.062	.067	.065
	5	.060	.058	.063	.061
	6	.056	.055	.059	.057
	7	.053	.052	.055	.054
	8	.051	.049	.052	.051
	9	.048	.047	.050	.049
	10	.046	.045	.047	.046
	11	.044	.043	.045	.044
	12	.042	.041	.043	.042

Siding Material/Framing Type

2 x 4 Single Stud: R-13 Batt

NOTE:
Nominal Batt R-value:
R-13 at 3.63-inch thickness

Installed Batt R-value:
R-12.7 in 3.5-inch cavity

	Siding Material/Framing Type			
	Lapped	Wood	T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	.082	.078	.088	.083
1	.075	.072	.080	.076
2	.069	.066	.073	.070
3	.065	.062	.068	.065
4	.060	.058	.063	.061
5	.057	.055	.059	.057
6	.053	.052	.056	.054
7	.051	.049	.052	.051
8	.048	.047	.050	.048
9	.046	.045	.047	.046
10	.044	.043	.045	.044
11	.042	.041	.043	.042
12	.040	.039	.041	.040

2 x 4 Single Stud: R-13 Blown In Blanket System

NOTE:
Nominal Batt R-value
R-3.8 per inch thickness

Installed Batt R-value
R-13.3 in 3.5-inch cavity

	Siding Material/Framing Type			
	Lapped	Wood	T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	.080	.076	.086	.080
1	.074	.070	.077	.074
2	.068	.065	.071	.068
3	.063	.060	.066	.063
4	.059	.057	.062	.059
5	.056	.053	.058	.056
6	.052	.051	.054	.052
7	.050	.048	.051	.050
8	.047	.046	.049	.047
9	.045	.044	.046	.045
10	.043	.042	.044	.043
11	.041	.040	.042	.041
12	.039	.038	.041	.039

2 x 6 Single Stud: R-19 Batt

	R-value of Foam Board	Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
Nominal Batt R-value	0	.062	.058	.055	.065	.061	.058
R-19 at 6-inch thickness							
	1	.058	.055	.052	.060	.057	.055
Installed Batt R-Value	2	.054	.052	.050	.056	.054	.051
R-18 in 5.5-inch cavity	3	.051	.049	.047	.053	.051	.049
	4	.048	.046	.045	.050	.048	.046
	.5	.046	.044	.043	.048	.046	.044
	.6	.044	.042	.041	.045	.044	.042
	.7	.042	.040	.039	.043	.042	.040
	.8	.040	.039	.038	.041	.040	.039
	.9	.038	.037	.035	.039	.038	.037
	10	.037	.036	.035	.038	.037	.036
	11	.036	.035	.034	.036	.035	.035
	12	.034	.033	.033	.035	.034	.033

2 x 6 Single Stud: R-21 High Density Batt or Blown In Blanket System

	R-value of Foam Board	Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
Nominal Batt R-value	0	.057	.054	.051	.060	.056	.053
R-21 at 5.5-inch thickness							
	1	.054	.051	.048	.056	.053	.050
Installed BIBS R-value	2	.050	.048	.045	.052	.050	.047
R-21 in 5.5-inch cavity	3	.048	.045	.043	.049	.047	.045
	4	.045	.043	.041	.047	.045	.043
Installed BIBS R-value	5	.043	.041	.040	.044	.042	.041
R-3.8 per inch thickness							
	6	.041	.039	.038	.042	.041	.039
BIBS Installed R-Value	7	.039	.038	.036	.040	.039	.037
R-20.9 in 5.5-inch cavity	8	.038	.036	.035	.039	.037	.036
	9	.036	.035	.034	.037	.036	.035
	10	.035	.034	.033	.036	.035	.033
	11	.033	.033	.032	.034	.033	.032
	12	.032	.031	.031	.033	.032	.031

2 x 6 Single Stud: R-22 Batt

NOTE:
Nominal Batt R-value
R-22 at 6.75-inch thickness

Installed Batt R-value
R-20 in 5.5-inch cavity

	Siding Material/Framing Type					
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	.059	.055	.052	.062	.058	.054
1	.055	.052	.049	.057	.054	.051
2	.052	.049	.047	.054	.051	.048
3	.049	.046	.044	.050	.048	.046
4	.046	.044	.042	.048	.046	.044
5	.044	.042	.041	.045	.043	.042
6	.042	.040	.039	.043	.042	.040
7	.040	.039	.037	.041	.040	.038
8	.038	.037	.036	.039	.038	.037
9	.037	.036	.035	.038	.037	.035
10	.035	.034	.033	.036	.035	.034
11	.034	.033	.032	.035	.034	.033
12	.033	.032	.031	.034	.033	.032

2 x 6 Single Stud: 2 R-11 Batts

NOTE:
Nominal Batt R-value
R-22 at 7-inch thickness

Installed Batt R-value
R-18.9 in 5.5-inch cavity

	Siding Material/Framing Type					
	Lapped Wood			T1-11		
R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
0	.060	.057	.054	.063	.059	.056
1	.056	.053	.051	.059	.056	.053
2	.053	.050	.048	.055	.052	.050
3	.050	.048	.046	.052	.049	.047
4	.047	.045	.044	.049	.047	.045
5	.045	.043	.042	.046	.045	.043
6	.043	.041	.040	.044	.043	.041
7	.041	.040	.038	.042	.041	.039
8	.039	.038	.037	.040	.039	.038
9	.038	.037	.036	.039	.038	.036
10	.036	.035	.034	.037	.036	.035
11	.035	.034	.033	.036	.035	.034
12	.034	.033	.032	.034	.034	.033

2 x 8 Single Stud: R-25 Batt

NOTE:
Nominal Batt R-value
R-25 at 8-inch thickness

Installed Batt R-value
R-23.6 in 7.25-inch cavity

	Siding Material/Framing Type					
	Lapped Wood			**T1-11**		
R-value of Foam Board	**STD**	**INT**	**ADV**	**STD**	**INT**	**ADV**
0	.051	.047	.045	.053	.049	.046
1	.048	.045	.043	.049	.046	.044
2	.045	.043	.041	.047	.044	.042
3	.043	.041	.039	.044	.042	.040
4	.041	.039	.037	.042	.040	.038
5	.039	.037	.036	.040	.038	.037
6	.037	.036	.035	.038	.037	.036
7	.036	.035	.033	.037	.035	.034
8	.035	.033	.032	.035	.034	.033
9	.033	.032	.031	.034	.033	.032
10	.032	.031	.030	.033	.032	.031
11	.031	.030	.029	.032	.031	.030
12	.030	.029	.028	.031	.030	.029

2 x 6: Strap Wall

	Siding Material/Frame Type			
	Lapped Wood		T1-11	
	STD	ADV	STD	ADV
R-19 + R-11 Batts	.036	.035	.038	.036
R-19 + R-8 Batts	.041	.039	.042	.040

2 x 6 + 2 x 4: Double Stud

Batt Configuration			Siding Material/Frame Type			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-19	------	R-11	.040	.037	.041	.038
R-19	------	R-19	.034	.031	.035	.032
R-19	R-8	R-11	.029	028	.031	.029
R-19	R-11	R-11	.027	.026	.028	.027
R-19	R-11	R-19	.024	.023	.025	.023
R-19	R-19	R-19	.021	.020	.021	.020

2 x 4 + 2 x 4: Double Stud

Batt Configuration			Siding Material/Frame Type			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-11	------	R-11	.050	.046	.052	.048
R-19	------	R-11	.039	.037	.043	.039
R-11	R-8	R-11	.037	.035	.036	.036
R-11	R-11	R-11	.032	.031	.033	.032
R-13	R-13	R-13	.029	.028	029	.028
R-11	R-19	R-11	.026	.026	.027	.026

Log Walls

NOTE:
R-value of wood:
R-1.25 per inch thickness

Average Wall Thickness
90% average log diameter

Average Log Diameter	U-value
6-inch	0.148
8-inch	0.111
10-inch	0.089
12-inch	0.074
14-inch	0.063
16-inch	0.056

Stress Skin Panel

NOTE:

R-value of expanded polystyrene:
R-3.85/inch

Framing: 6%
Spline: 8%
No thermal bridging between interior and exterior splines

Panel Thickness	U-value
3 1/2-inch	.071
5 1/2-inch	.040
7 1/4-inch	.037
9 1/4-inch	.030
11 1/4-inch	.025

CHAPTER 6.0: DOORS

6.1 General: Table 6.1 lists heat-loss coefficients for exterior doors in units of BTU/°F-hr per ft^2 of door. They are derived from data provided in the 1989 ASHRAE Handbook of Fundamentals, Chapter 22, and from a compilation of U-values tested according to AAMA or ASTM standards.

6.2 Component Description: Doors are assumed to be wood or metal with no glazing. These defaults may be used for the opaque portions of doors with less than 50 percent of their total area in glass.

Glazing areas in doors shall use the appropriate default U-value in Chapter 7 for the specific glazing type. Doors with more than 50 percent glazing area are considered entirely window and must use window default U-values in Chapter 7 for the entire door area.

Metal doors are assumed to have thermally broken frames and coefficients include heat loss through frames.

Storm door material is assumed to be the same as the primary door.

6.3 7.5-MPH Adjustment: Coefficients listed under Table 6.1 "15 mph Default Door U-values" shall be used for compliance. When qualifying homes using the Thermal Performance or Energy Budget methods, the Default U-values shall be adjusted to 7.5-mph equivalent values using the following equation:

$$U(7.5mph) = U(15mph) \times 0.931 + .0126$$

where:
U(7.5mph) = default U-value adjusted to 7.5-mph wind speed conditions
U(15mph) = default U-value at 15-mph wind speed conditions

Note: This adjustment is made automatically in the WATTSUN program. Therefore, use the 15-mph U-values when running WATTSUN.

TABLE 6-1: DEFAULT U-VALUES FOR EXTERIOR DOORS
15-mph Default U-VALUES

Type		w/storm
Metal, 1 3/4-inch, solid core urethane flush	0.14	--
Wood, 1 3/8-inch, solid core flush	0.39	0.26
Wood, 1 3/8-inch, solid core panel	0.57	0.33
Wood, 1 3/8-inch, hollow core flush	0.47	0.30
Wood, 1 3/4-inch, solid core flush	0.33	0.28
Wood, 1 3/4-inch, solid core panel	0.57	0.33
Wood, 1 3/4-inch, hollow core flush	0.46	0.29
Wood, 2 1/4-inch, solid core flush	0.27	0.20

TABLE 6-2
GLAZED ENTRY DOOR DEFAULT U-FACTORS

15-mph Default U-factors

DESCRIPTION	DOOR MATERIAL: INSULATED 35-50% Glass[8]	INSULATED Below 35% Glass	WOOD 35-50% Glass[8]	WOOD Below 35% Glass
Single	0.67	0.53	0.81	0.72
Double, Clear 1/4"	0.39	0.31	0.47	0.42
Double, Clear 1/4" + Argon	0.37	0.30	0.45	0.41
Double, Low-e4 1/4"	0.36	0.30	0.44	0.41
Double, Low-e2 1/4"	0.35	0.29	0.43	0.40
Double, Low-e1 1/4"	0.24	0.28	0.41	0.39
Double, Low-e4 1/4" + Argon	0.33	.028	0.41	0.39
Double, Low-e2 1/4" + Argon	0.31	0.26	0.39	0.38
Double, Low-e1 1/4" + Argon	0.31	0.26	0.38	0.37
Double, Clear 3/8"	0.37	0.30	0.45	0.41
Double, Clear 3/8" + Argon	0.36	0.29	0.44	0.41
Double, Low-e4 3/8"	0.34	0.28	0.42	0.40
Double, Low-e2 3/8"	0.33	0.28	0.41	0.39
Double, Low-e1 3/8"	0.21	0.26	0.38	0.37
Double, Low-e4 3/8" + Argon	0.32	0.27	0.40	0.38
Double, Low-e2 3/8" + Argon	0.29	0.25	0.37	0.37
Double, Low-e1 3/8" + Argon	0.29	0.25	0.36	0.36
Double, Clear 1/2"	0.36	.029	.044	0.41
Double, Clear 1/2" + Argon	0.34	0.28	0.42	0.40
Double, Low-e4 1/2"	0.32	0.27	0.40	0.38
Double, Low-e2 1/2"	0.30	0.26	0.38	0.37
Double, Low-e1 1/2"	0.29	0.25	0.36	0.36
Double, Low-e4 1/2" + Argon	0.30	0.26	0.38	0.37
Double, Low-e2 1/2" + Argon	0.28	0.25	0.36	0.36
Double, Low-e1 1/2" + Argon	0.28	0.24	0.34	0.35
Triple, Clear, 1/4"	0.31	0.26	0.39	0.38
Triple, Clear 1/4" + Argon	0.29	0.25	0.37	0.37
Triple, Low-e4 1/4"	0.30	0.26	0.38	0.37
Triple, Low-e2 1/4"	0.29	0.25	0.37	0.36
Triple, Low-e4 1/4" + Argon	0.27	0.24	0.35	0.35
Triple, Low-e2 1/4" + Argon	0.26	0.24	0.34	0.35

1. Subtract 0.02 from the listed U-factors for insulated spacers (fiber glass, wood, butyl or equivalent k-value).
2. Low-e4, emissivity = 0.4 or less: Low-e2, emissivity = 0.2 or less; Low-e1, emissivity = 0.1 or less.
3. Add 0.05 for insulated doors without a thermal break and more than 35 percent glazing.
4. Add 0.06 for insulated doors without a thermal break and less than 35 percent glazing.
5. Add 0.03 for dividers between the glazing with less than 1/8" between the divider and each lite.
6. Argon includes CO_2, SF_6, and argon/SF_6 mixtures.
7. Krypton with a space of 1/4" or more equals argon with a space of 1/2" or more.
8. Use window default U-factors for more than 50% glazing.

CHAPTER 7.0: GLAZING

7.1 General: Table 7.1 lists heat-loss coefficients for exterior windows and skylights in units are BTU/°F-hr per square foot of glazing. They are derived from data provided in the 1989 ASHRAE Handbook of Fundamentals, Chapter 27, the 1958 ASHAE Guide, and a compilation of actual tested U-values taken from the Seattle Department of Construction and Land Use Client Assistance Memo #403 "Glazing U-Values Acceptable For Demonstrating Compliance With The 1986 Energy Code," December 1988.

7.2 Framing Description: Coefficients are listed for framing meeting the following descriptions:

Wood or Vinyl: Wood and vinyl-framed windows having wood and/or vinyl as the primary material of the frame.

Wood with Exterior Aluminum Cladding (Wood w/EAC): Wood-framed windows having an exterior aluminum surface.

Aluminum (Alum): Nonthermally improved metal-framed windows without a thermal break between interior and exterior frame surfaces.

Aluminum with Thermal Break (Alum w/T.B.): Thermally-improved, metal-framed windows having a continuous thermal break with a minimum of 0.25-inches of low-conductivity material installed between the sealed glazing unit and the exterior surfaces of any metal retaining frame, sash, and center pieces (mullions, etc.). If the window is not constructed with a sealed glazing unit, a thermal barrier shall be installed between the layers of glazing.

7.3 Glazing Description: Coefficients are listed for units with a minimum 1/2-inch air space between glazing layers. All coefficients include window-frame and sash heat loss. Window area is based on rough opening dimensions. Storm windows are considered an additional layer of glazing. Windows with metal or other decorative mullions placed between glazing layers must be tested with mullions in place, and are not covered in these default values. Door glazing and side lites are considered windows and calculated separately from the opaque portions of doors. Doors with over 50-percent glazing are considered all window, and shall use window defaults for the entire opaque and nonopaque area. Window default U-values include patio doors, sliding glass doors and storm doors.

2Gl: Double-glazed windows

3Gl: Triple-glazed windows

Ar: Sealed insulated glass unit with argon gas filling the space between glazing layers.

Low-E: Low emittance coating applied to the #2 or #3 glazing surface of a sealed insulated glass unit, or applied to a film suspended between two glazing layers.

7.4 7.5-MPH Adjustment: Coefficients listed under Table 7.1(a) "15 mph Default Window U-values" and "15-mph Default Skylight U-values" shall be used for compliance. When qualifying homes using the Thermal Performance or Energy Budget methods, the Default U-values shall be adjusted to 7.5-mph equivalent values with the following equation:

U(7.5mph) = U(15mph) x 0.931 + .0126

where:
U(7.5mph) = default U-Value adjusted to 7.5-mph wind speed conditions
U(15mph) = default U-Value at 15-mph wind speed conditions

Note: This adjustment is made automatically in the WATTSUN program. Use 15-mph U-values when running WATTSUN.

TABLE 7.1

Default U-Factors for Glazing

Window Type	Frame Type			
	Metal	Alum. with Therm. Break	Wood/Vinyl	Al. Clad Wood/ Reinforced Vinyl
Double, clear, 1/4"	0.82	0.66	0.56	0.59
Double, clear, 3/8"	0.78	0.63	0.54	0.57
Double, clear, 1/2"	0.75	0.60	0.50	0.54
Double, Argon, 1/4"	0.77	0.63	0.53	0.56
Double, Argon, 3/8"	0.75	0.60	0.51	0.54
Double, Argon, 1/2"	0.72	0.58	0.48	0.51
Double, Low-e.2, 1/4"	0.73	0.58	0.49	0.51
Double, Low-e.2, 3/8"	0.69	0.54	0.45	0.48
Double, Low-e.2, 1/2"	0.64	0.50	0.40	0.44
Dbl., Low-e.2, Ar., 1/4"	0.66	0.52	0.43	0.46
Dbl., Low-e.2, Ar., 3/8"	0.63	0.49	0.41	0.44
Dbl., Low-e.2, Ar., 1/2"	0.6	0.46	0.37	0.40
Triple, Clear, 1/4"	0.66	0.52	0.42	0.44
Triple, Clear, 1/2"	0.61	0.46	0.37	0.40
Triple, Argon, 1/4"	0.63	0.49	0.39	0.42
Triple, Argon, 1/2"	0.59	0.45	0.36	0.38
Triple, Low-e.2, 1/4"	0.62	0.48	0.39	0.41
Triple, Low-e.2, 1/2"	0.55	0.41	0.32	0.35
Trp., Low-e.2, Ar., 1/4"	0.58	0.43	0.34	0.37
Trp., Low-e.2, Ar., 1/2"	0.52	0.38	0.30	0.32

1. If the Low-e coating has an emissivity greater than 0.2, add 0.03 to the U-factor.
2. If the Low-e coating has an emissivity of 0.1, subtract 0.02 from the U-factor.
3. Subtract 0.02 from the U-factor for windows that have an insulated spacer.

Glass Block	
6"x 6"x4" nominal	0.60
8"x 8"x4" nominal	0.56
12"x12"x4" nominal	0.52

Glazing type	15-mph Skylight U-values Frame type			
	Vinyl or Wood	Wood w/EAC	w/T.B.	Alum
2Gl	0.65	0.69	0.73	0.82
2Gl + Ar	0.60	--	0.70	0.77
2Gl + Low-E	0.52	0.52	0.64	0.70
2Gl + Ar + Low-E	--	0.45	0.50	
3Gl	0.51	--	0.64	
3Gl + Low-E	0.42	--	0.57	--

CHAPTER 8: CEILINGS

8.1 General: Table 8.1 lists heat-loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings, and roof decks in units of BTU/°F-hr per square foot of ceiling.

They are derived from procedures listed in the 1989 ASHRAE Handbook of Fundamentals. Ceiling U-values are modified for the buffering effect of the attic, assuming an indoor temperature of 65°F and an outdoor temperature of 45°F.

8.2 Component Description: The three types of ceilings are characterized as follows:

Ceilings Below a Vented Attic: Attic insulation is assumed to be blown-in, loose-fill fiberglass with a K-value of 2.6 Hr-°F-ft2/BTU per inch. Full bag count for specified R-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are 45 X 30 feet, with a gabled roof having a 4/12-pitch. The attic is assumed to vent naturally at the rate of 3 ACH through soffit and ridge vents. A void fraction of 0.002 is assumed for all attics with insulation baffles. Standard-framed, unbaffled attics assume a void fraction of 0.008.

Attic framing is either standard or advanced. Standard framing assumes tapering of insulation depth around the perimeter with resultant decrease in thermal resistance. An increased R-value is assumed in the center of the ceiling due to the effect of piling leftover insulation. Advanced framing assumes full and even depth of insulation extending to the outside edge of exterior walls.

Vented scissors truss attics assume a ceiling pitch of 2/12 with a roof pitch of either 4/12 or 5/12. Unbaffled standard framed scissors truss attics are assumed to have a void fraction of 0.016.

Vaulted Ceilings: Insulation is assumed to be fiberglass batts installed in roof joist cavities. In the vented case, at least 1.5 inches between the top of the batts and the underside of the roof sheathing is left open for ventilation in each cavity. A ventilation rate of 3 ACH is assumed. In the unvented or dense pack case, the ceiling cavity is assumed to be fully packed with insulation, leaving no space for ventilation.

Roof Decks: Rigid insulation is applied to the top of roof decking with no space left for ventilation. Roofing materials are attached directly on top of the insulation. Framing members are often left exposed on the interior side.

TABLE 8-1: DEFAULT U-VALUES FOR CEILINGS

Ceilings Below Vented Attics	Standard Frame		Advanced Frame
Flat Ceiling	Baffled	Unbaffled	
R-19	0.049	0.052	0.047
R-30	0.036	0.038	0.032
R-38	0.031	0.034	0.026
R-49	0.027	0.030	0.020
R-60	0.025	0.028	0.017
Scissors Truss			
R-30 (4/12 roof pitch)	0.043	0.049	0.031
R-38 (4/12 roof pitch)	0.040	0.046	0.025
R-49 (4/12 roof pitch)	0.038	0.044	0.020
R-30 (5/12 roof pitch)	0.039	0.046	0.032
R-38 (5/12 roof pitch)	0.035	0.042	0.026
R-49 (5/12 roof pitch)	0.032	0.039	0.020

Vaulted Ceilings	16" O.C.	24" O.C.
Vented		
R-19 2x10 joist	0.049	0.048
R-30 2x12 joist	0.034	0.033
R-38 2x14 joist	0.027	0.027
Unvented		
R-30 2x10 joist	0.034	0.033
R-38 2x12 joist	0.029	0.027
R-21 + R-21 2x12 joist	0.026	0.025

Roof Deck	4x Beams, 48" O.C.
R-12.5 2" Rigid insulation	0.064
R-21.9 3.5" Rigid insulation	0.040
R-37.5 6" Rigid insulation	0.025
R-50 8" Rigid insulation	0.019

CHAPTER 9: AIR INFILTRATION

9.1 General: Tables 9.1 and 9.2 list effective air-change rates and heat capacities for heat loss due to infiltration.

Estimated seasonal average infiltration rates in air changes per hour (ACH) are given for the two levels of air-leakage control (see section 4.6 of the Technical Specifications). The energy-effective air-change rate shall be used in calculations for compliance under Thermal Performance or Energy Budgets. Advanced air-leakage control assumes the use of a heat recovery ventilation system providing a continuous airflow of 0.25 ACH with 60 percent heat recovery.

Heat loss due to infiltration shall be computed using the following equation:

$$Q_{infil} = ACH_{eff} * HCP$$

where:

Q_{infil} = Heat loss due to air infiltration

ACH_{eff} = the effective infiltration rate as given in Table 9-1

HCP = the Heat Capacity Density Product for the appropriate elevation or climate zone as given below.

Table 9-1 ASSUMED EFFECTIVE AIR-CHANGES PER HOUR

Air-Leakage Control Package	Air-Changes per Hour Natural	Effective
Standard	0.35	0.35
Advanced	0.10	0.20

Table 9-2 DEFAULT HEAT CAPACITY/DENSITY PRODUCT FOR AIR

Heating Zone	Average Elevation	Heat Capacity/Density
1	Mean Sea Level	0.0180 BTU/Hr-°F
2	2000	0.0168
3	3000	0.0162

CHAPTER 10: MASS

10.1 General: Table 10.1 lists default mass-values for residential construction types. All calculations are based on standard ASHRAE values for heat-storage capacity as listed in 1989 Handbook of Fundamentals, Chapter 22.

Thermal capacity of furniture is ignored, as is heat storage beyond the first 4 inches of mass thickness. All mass is assumed to be in direct contact with the conditioned space. Concrete separated from the heated volume by other materials must multiply the listed concrete mass value by the result of the following formula:

Ln(R-value) x (-.221) + 0.5
Where:

Ln = Natural log
R-value = R-value of material covering concrete

Note: All default values for covered concrete slabs have been adjusted according to this procedure.

10.2 Mass Description: Mass is divided into two types, structural and additional.

Structural Mass: Includes heat-storage capacity of all standard building components of a typical residential structure, including floors, ceilings, and interior and exterior walls in Btu/°F-ft^2 of floor area. It also assumes exterior wall, interior wall and ceiling surface area approximately equals three times the floor area.

Additional Mass: Includes any additional building material not part of the normal structure, which is added specifically to increase the building's thermal-storage capability. This category includes masonary fireplaces, water or Trombe walls, and extra layers of sheetrock. Coefficients are in Btu/°F-ft^2 of surface area of material exposed to conditioned space. The coefficient for water is BTU/°F-Gallon.

10.3 Component Description: Light frame assumes 1-inch thick wood flooring with 5/8-inch sheetrock on ceilings and interior walls, and walls consisting of either 5/8-inch sheetrock or solid logs. Slab assumes a 4-inch concrete slab on or below grade, with 5/8-inch sheetrock on exterior and interior walls and ceiling, and with separate values for interior or exterior wall insulation. Adjustments for slab covering is based on R-value of material. Additional mass values are based on the density multiplied by the specific heat of the material adjusted for listed thickness.

Table 10-1 DEFAULT MASS VALUES

Structural Mass M-value	$Btu/°F\text{-}Ft^2$ floor area
Light frame:	
Joisted/post and beam floor, sheetrock walls and ceilings	3.0
Joisted/post and beam floor, log walls, sheetrock ceilings	4.0
Slab with interior wall insulation:	
Slab, no covering or tile, sheetrock walls and ceilings	10.0
Slab, hardwood floor covering, sheetrock walls and ceilings	7.0
Slab, carpet and pad, sheetrock walls and ceilings	5.0
Slab with exterior wall insulation:	
Slab, no covering or tile, sheetrock walls and ceilings	12.0
Slab, hardwood floor covering, sheetrock walls and ceilings	9.0
Slab, carpet and pad, sheetrock walls and ceilngs	7.0

Additional Mass M-Value	$BTU/°F\text{-}Ft^2$ surface area
Gypsum wallboard, 1/2-inch thickness	0.54
Gypsum wallboard, 5/8-inch thickness	0.68
Hardwood floor	1.40
Concrete/Brick, 4-inch-thickness	10.30
Concrete/Brick, 4-inch-thickness	15.40
	BTU/°F-gallon
Water, 1 gallon	8.0